BELL TELEPHONE QUARTERLY

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JULY, 1931

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AMERICAN TELEPHONE & TELEGRAPH CO.
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A Medium of Suggestion and a Record of Progress

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International Radio Technical Conference at Copenhagen[1]

TOWARD the end of May, about 200 representatives from some 35 different countries met at Copenhagen, Denmark, to study the technical problems involved in the use of the common radio medium by the nations of the world. This gathering was the second meeting of the International Technical Consulting Committee on Radio Communication (C. C. I. R.) which was formed under the international treaty known as the Washington Radio Convention of 1927. This committee, as is indicated by its title, is advisory in character and deals with technical and engineering questions.

The questions studied are concerned largely with the reduction of interference between radio stations, including such factors as the degree to which radio stations may be expected to hold their frequencies constant and to confine their emissions to very narrow bands. While the technical advance represented by the findings of the meeting cannot be said to be as outstanding as that represented by the work of the previous meeting at The Hague in 1929, nevertheless the progress has been fully as great, particularly in respect to the consolidation of technical ideas concerning the problem of interference and the better *recognition* of the technical requirements which need to be observed.

Perhaps the most important single technical recommendation is that indicating the degree of constancy with which radio stations engaged in various services should be expected to hold their frequencies. The Copenhagen recommendation slightly relaxes the figures which the Hague Meeting had suggested for observance in the future, a result of a better appreciation of the practical difficulties involved. This very appreciation, coupled with the desire evidenced by all concerned to observe

[1] L. Espenschied, High Frequency Transmission Engineer, L. E. Whittemore, Special Radio Representative, both of the American Telephone and Telegraph Company, and W. Wilson, Assistant Director of Research of the Bell Telephone Laboratories, Inc., attended this conference as representatives of the Bell System in the United States delegation.—*Editor.*

the recommendations, represents real progress in the international co-ordination of radio channels.

Advice is given for the first time on several specific radiotelephone problems. The Conference has taken account of ship-to-shore radiotelephony and has drawn up a set of guiding principles for the establishment of systems engaged in this service, following the experience which has been obtained in the operation of the ship-to-shore telephone systems on the North Atlantic. The recommendation upon the subject includes information on the appropriate relations between the frequencies to be used for this service but does not go so far as to allocate frequencies.

The question of selectivity of receiving sets was discussed at the meeting but the study had not been carried far enough to permit of definite recommendations. It was left over for further study.

A related question which has now been raised for the first time before the C. C. I. R. is that of interference with radio reception from man-made sources, such as electrical contacts of various kinds. This refers especially to interference with broadcast reception in the home. Denmark has undertaken to act as a centralizing administration in collecting the information.

The problem, of how and for what purpose the various frequencies of the radio spectrum are to be used, is of course, a fundamental one in the whole radio situation. It involves other and even more important factors than the purely technical. The C. C. I. R. has no authority to deal with this question, and both the Hague and the Copenhagen Meetings have taken care to avoid it. However, it is distinctly in the background of the technical meetings, and the technical recommendations are carefully weighed in terms of their effect upon it. In fact it is because of this question of frequency allocation that the C. C. I. R. has considerably more governmental interest and is more formal in its conduct than are the corresponding telephone and telegraph technical committees which

derive their authority under the International Wire Convention of St. Petersburg.

It is, therefore, of no small interest that the Copenhagen Conference has agreed that the C. C. I. R. would undertake a study of the physical side of this problem, i.e. of the uses to which the different frequencies are best adapted by virtue of their propagation characteristics. This study is to be co-ordinated by Great Britain, with a number of other nations collaborating, including the United States. It is planned that results from the study will be available in time for use at the next general radio conference which is to be held at Madrid in September, 1932.

The most immediate problem which has given rise to the need for this study is the desire on the part of the European broadcasting interests to make further use of the longer wave portion of the spectrum for European broadcasting. Such use would make inroads on the channels used for maritime services, and this in turn raises the question of the dependence which maritime communications may place upon the shorter waves. Naturally, any move in the direction of changing the uses to be made of certain wave bands is a disturbing factor and will raise the question whether the advantage is sufficiently outstanding to justify the undertaking of a readjustment, involving as it may serious economic, political and even juridical problems. Such questions as these can be dealt with only at major conferences such as that due to be held in Madrid in 1932. The agreement at Copenhagen to get in hand the physical facts of the case reflects a progressive and constructive attitude on the part of the conference members and may prove to be the most important outcome of the Copenhagen meeting.

No note on this conference would be complete without mention of the splendid facilities for it provided by the Danish Government. The great parliamentary building, Christiansborg Slot, was put at the disposal of the Meeting and the kindness and hospitality of the people of Denmark were evidenced on every occasion.

LLOYD ESPENSCHEID

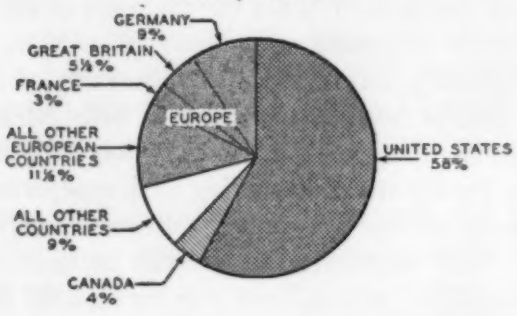
World's Telephone Statistics

January 1, 1930

"I WAS 21 when I made the first telephone for Bell and I am still going strong." Thus spoke Dr. Thomas H. Watson before a gathering of telephone men in Indianapolis in the early part of May of this year. Watson constructed the first telephone in 1875. The latest world survey of telephone growth and development indicates that there were, on January 1, 1930, 34,526,629 telephones throughout the world. The rapidity of the growth of this means of communication, which has developed into a world-wide network of interconnected instruments during the lifetime of one man, can hardly be ap-

DISTRIBUTION OF THE WORLD'S TELEPHONES

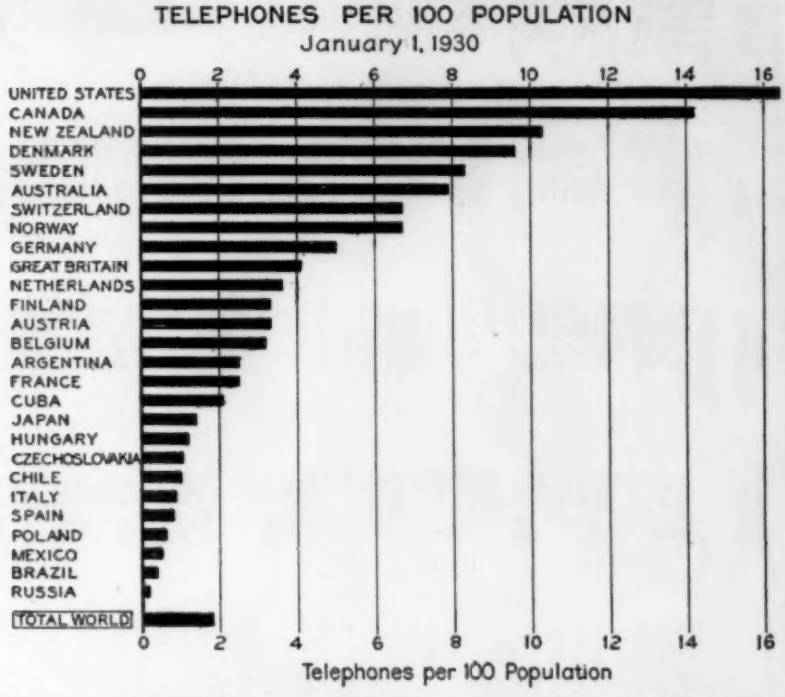
January 1, 1930



preciated even by telephone people themselves. In fact, the telephone had reached its quasi-majority of twenty-one years of useful service before 80 per cent of the present Bell System workers were born.

This recent survey, conducted by the Chief Statistician's Division of the American Telephone and Telegraph Company, indicates that 1,962,409 instruments were added to the telephone networks throughout the world during the year 1929. This increase appears more significant when it is recalled that

there were fewer than this number of telephones in the world at the beginning of the present century. Of the total number of telephones in the world on January 1, 1930, 20,068,023, or more than 58 per cent, were located in the United States; more than 99 per cent of these telephones were either owned by or connected to the Bell System. On the same date, Europe had 10,035,580 telephones, representing 29 per cent of the total in the world. The remaining 13 per cent of the world's tele-



phones were distributed among the countries of Asia, Africa, Oceania, South America and North America other than the United States.

The survey involved the gathering of authoritative information through correspondence with telephone officials in all foreign countries. As in former years, the data have been collated and printed in a pamphlet from which the accompanying tables and charts have been reproduced.

TELEPHONE DEVELOPMENT OF THE WORLD, BY COUNTRIES

January 1, 1930

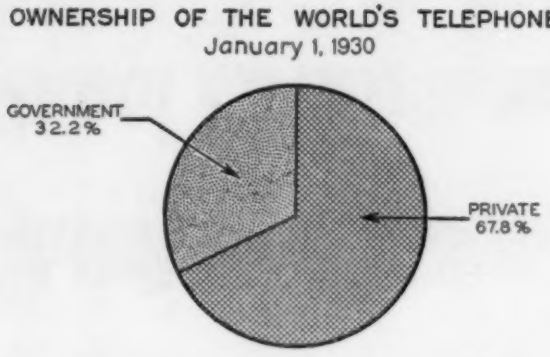
	Number of Telephones			Percent of Total World	Telephones per 100 Population	Increase in Number of Telephones During 1929
	Government Systems	Private Companies	Total			
NORTH AMERICA:						
United States	.....	20,068,023	20,068,023	58.12%	16.4	891,715
Canada	247,642	1,152,344	1,399,986	4.06%	14.2	65,452
Central America	11,892	12,739	24,631	.07%	0.4	974
Mexico	1,427	80,268	81,695	.24%	0.5	3,724
West Indies:						
Cuba	485	76,332	76,817	.22%	2.1	3,104
Porto Rico	404	11,856	12,260	.04%	0.8	—716
Other W. I. Places*	9,303	11,252	20,555	.06%	0.3	573
Other No. Am. Places*	100	11,309	11,409	.03%	3.2	1,214
Total	271,253	21,424,123	21,695,376	62.84%	13.0	966,040
EUROPE:						
Austria	222,236	.....	222,236	.64%	3.3	12,766
Belgium	259,673	.....	259,673	.75%	3.2	33,828
Bulgaria	18,505	.....	18,505	.05%	0.3	1,414
Czechoslovakia	142,413	15,294	157,707	.46%	1.1	13,399
Denmark (March 31, 1930)	13,309	328,490	341,799	.99%	9.6	10,751
Finland	1,314	120,750	122,064	.35%	3.3	7,273
France	1,056,034	.....	1,056,034	3.06%	2.5	90,515
Germany	3,182,305	.....	3,182,305	9.22%	5.0	231,875
Great Britain and No. Ireland	1,886,726	.....	1,886,726	5.47%	4.1	127,040
Greece*	13,000	.....	13,000	.04%	0.2	3,000
Hungary	100,590	.....	100,590	.29%	1.2	7,431
Irish Free State (March 31, 1930)	27,992	.....	27,992	.08%	0.9	1,054
Italy (June 30, 1930)	.....	381,992	381,992	1.11%	0.9	48,935
Jugo-Slavia	66,863	.....	66,863	.19%	0.4	5,000*
Latvia (March 31, 1930)	42,189	.....	42,189	.12%	2.2	7,742
Netherlands	284,433	.....	284,433	.82%	3.6	28,944
Norway	111,238‡	77,000*	188,238	.55%	6.7	3,341
Poland	102,465	83,637	186,102	.54%	0.6	11,000*
Portugal	7,877	26,681	34,558	.10%	0.6	5,000*
Roumania	56,038	.....	56,038	.16%	0.3	1,000*
Russia (October 1, 1929)‖	331,252	.....	331,252	.96%	0.2	38,437
Spain	.....	184,542	184,542	.54%	0.8	38,209
Sweden	507,325	1,736	509,061	1.47%	8.3	23,310
Switzerland	268,714	.....	268,714	.78%	6.7	24,466
Other Places in Europe*	93,255	19,712	112,967	.33%	1.3	5,460
Total	8,795,746	1,239,834	10,035,580	29.07%	1.9	781,190

SOUTH AMERICA:						
Argentina	.....	279,990	279,990	.81%	2.5	40,410
Bolivia	.....	2,507	2,507	.01%	0.1	—176
Brazil	674§	159,283	159,957	.46%	0.4	30,128
Chile	.....	45,239	45,239	.13%	1.0	3,123
Colombia	2,297	26,075	28,372	.08%	0.3	5,972
Ecuador	1,454§	2,693	4,147	.01%	0.2	—100*
Paraguay	185	1,785	1,970	.01%	0.3	907
Peru	.....	13,299	13,299	.04%	0.2	—566
Uruguay	.....	29,022	29,022	.08%	1.6	893
Venezuela	668§	19,182	19,850	.06%	0.6	5,217
Other So. Am. Places	2,768	.....	2,768	.01%	0.5	49
Total	8,046	579,075	587,121	1.70%	0.7	85,857
ASIA:						
British India (March 31, 1930)	21,810	35,091	56,901	.16%	0.02	3,216
China*	90,000	66,000	156,000	.45%	0.04	1,000
Japan (March 31, 1930)	865,516	.....	865,516	2.51%	1.4	54,197
Other Places in Asia*	105,795	16,796	122,591	.36%	0.1	9,151
Total	1,083,121	117,887	1,201,008	3.48%	0.1	67,564
AFRICA:						
Egypt	44,834	.....	44,834	.13%	0.2	1,610
Union of South Africa†	108,937	.....	108,937	.31%	1.4	6,629
Other Places in Africa*	81,023	1,314	82,337	.24%	0.1	8,507
Total	234,794	1,314	236,108	.68%	0.2	16,746
OCEANIA:						
Australia‡	505,554	.....	505,554	1.46%	7.9	28,854
Dutch East Indies	48,571	4,800	53,371	.15%	0.1	4,170
Hawaii	.....	24,366	24,366	.07%	6.6	1,700
New Zealand†	161,041	.....	161,041	.47%	10.3	8,500
Philippine Islands	5,832	17,072	22,904	.07%	0.2	1,488
Other Places in Oceania*	3,500	700	4,200	.01%	0.3	300
Total	724,498	46,938	771,436	2.23%	1.0	45,012
TOTAL WORLD	11,117,458	23,409,171	34,526,629¶	100.00%	1.8	1,962,409

* Partly estimated.
† March 31, 1930.
‡ June 30, 1929.
§ January 1, 1929.
‖ U.S.S.R., including Siberia and Associated Republics.
¶ Includes approximately 9,060,000 automatic or dial telephones, of which more than 50 percent are in the United States.

Comparative Telephone Development of Countries

No change occurred during 1929 in the relative standing of the principal countries as regards telephone development. The United States still headed the roll of nations with 16.4 telephones per 100 population. Canada with 14.2, New Zealand



with 10.3, and Denmark with 9.6 telephones per 100 population, were, respectively, second, third and fourth. Although Denmark ranked fourth in relative telephone development among the countries of the world, it was first in rank among the European countries. The next highest European country was Sweden with 8.3 telephones per hundred population, or about one-half the relative development in the United States. Norway and Switzerland each with 6.7 telephones per hundred population, ranked next. The chief European countries, Germany, Great Britain and France, were, however, distinctly below the leaders in telephone development, having 5.0, 4.1 and 2.5 telephones per 100 population, respectively. Of the South American countries, Argentina, with 2.5 telephones per 100 population, had by far the greatest telephone density. About 72 per cent of all the telephones in Asia were in Japan, although this Island Empire had no more than 1.4 telephones for each 100 inhabitants. The relative position of the principal countries of the world in point of telephone density is shown by the chart, "Telephones per 100 Population."

TELEPHONE DEVELOPMENT OF LARGE AND SMALL COMMUNITIES

January 1, 1930

Country	Service Operated by (See Note)	Number of Telephones		Telephones per 100 Population	
		In Communities of 50,000 Population and Over	In Communities of less than 50,000 Population	In Communities of 50,000 Population and Over	In Communities of less than 50,000 Population
Australia (June 30, 1929)*	G.	289,961	215,593	9.1	6.8
Austria	G.	167,842	54,394	7.2	1.2
Belgium	G.	182,833	76,840	5.6	1.6
Canada	P. G.	713,000	686,986	23.3	10.1
Czechoslovakia	P. G.	64,424	93,283	4.6	0.7
Denmark	P. G.	152,267	189,532	16.4	7.2
France	G.	616,978	439,056	6.9	1.3
Germany	G.	1,948,317	1,233,988	9.2	2.9
Great Britain and No. Ireland†	G.	1,361,000	559,000	5.6	2.6
Japan (March 31, 1930)	G.	507,401	358,115	3.7	0.7
Netherlands	G.	182,106	102,327	6.2	2.1
New Zealand (March 31, 1930)	G.	61,095	99,946	12.0	9.5
Norway	P. G.	63,824	122,964	15.8	5.1
Poland	P. G.	98,957	87,145	2.7	0.3
Sweden	G.	202,899	306,162	21.0‡	5.9
Switzerland	G.	118,395	150,319	14.6	4.7
United States	P.	11,106,320	8,961,703	22.9	12.1

Note: P. indicates telephone service operated by private companies, G. by the Government, and P. G. by both private companies and the Government. See first table.

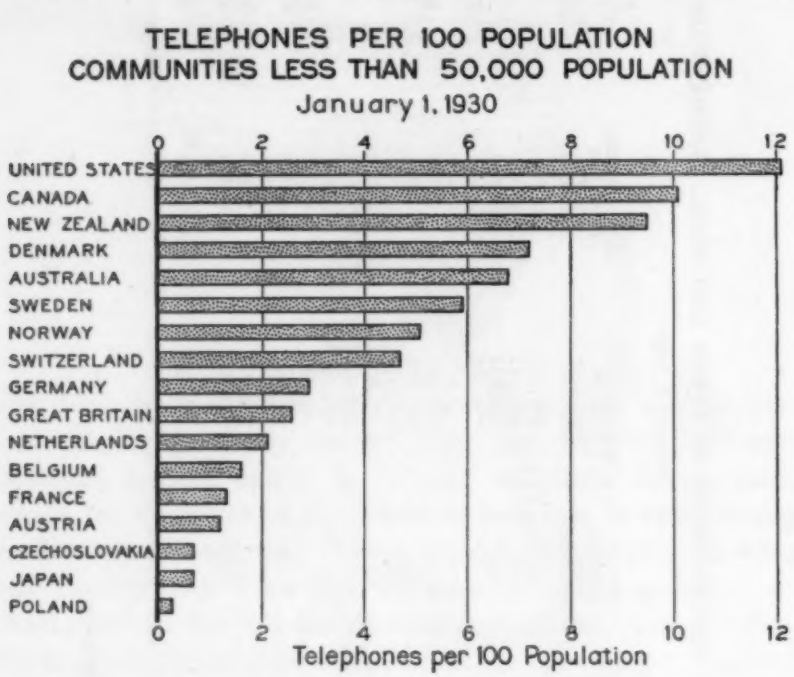
* Partly estimated.

† March 31, 1930.

‡ The majority of this development is due to Stockholm.

Telephones in Large and Small Communities

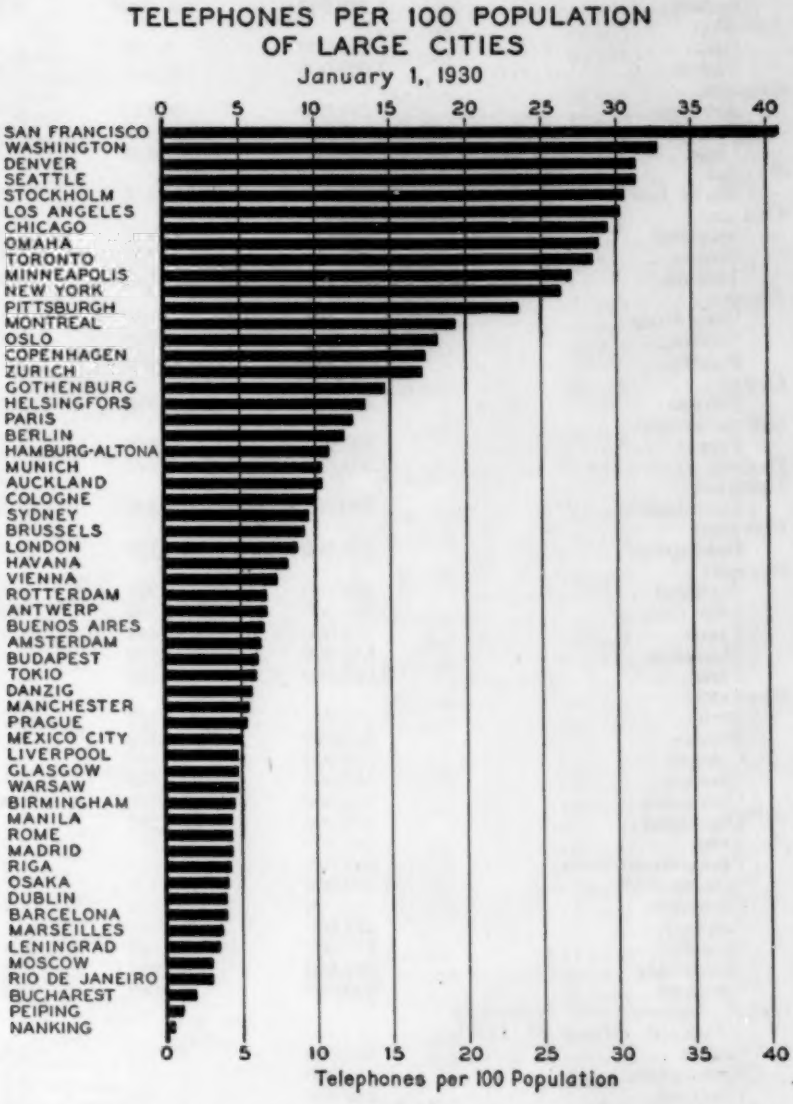
The table, "Telephone Development in Large and Small Communities," indicates the relative extent to which telephone service in the principal countries is made available in the smaller communities. That the less populated sections of the United



States are well provided with telephone facilities is evident from the fact that there are 12.1 telephones for each 100 inhabitants of communities of less than 50,000 population, a degree of development which exceeds the *total* development of any other country with the exception of Canada. Compared with conditions existing in the United States, rural telephone development may, in fact, be said to be practically non-existent in the principal European countries. Germany had a development of only 2.9 telephones per 100 inhabitants in communities of less than 50,000 population, Great Britain had 2.6, and France, 1.3.

TELEPHONES IN LARGE CITIES

The fact that the telephone service in foreign countries is



confined largely to the more densely populated regions is also reflected by the figures in the table, "Telephone Development

TELEPHONE DEVELOPMENT OF LARGE CITIES
January 1, 1930

Country and City (or Exchange Area)	Estimated Population (City or Exchange Area)	Number of Telephones	Telephones per 100 Population
ARGENTINA:			
Buenos Aires	2,300,000	149,968	6.5
AUSTRALIA:			
Adelaide	325,000	32,035	9.9
Brisbane	319,000	24,580	7.7
Melbourne	1,018,000	96,181	9.4
Sydney	1,239,000	118,269	9.5
AUSTRIA:			
Graz	164,000	8,719	5.3
Vienna	2,000,000	148,432	7.4
BELGIUM:			
Antwerp	519,000	34,813	6.7
Brussels	938,000	86,635	9.2
Liege	423,000	17,824	4.2
BRAZIL:			
Rio de Janeiro	1,500,000	44,144	2.9
CANADA:			
Montreal	975,000	187,985	19.3
Ottawa	183,000	37,750	20.6
Toronto	710,000	201,419	28.4
CHINA:			
Hong Kong	500,000	11,937	2.4
Nanking	500,000	2,749	0.5
Peiping	1,200,000	12,830	1.1
CUBA:			
Havana	650,000	52,659	8.1
CZECHOSLOVAKIA:			
Prague	732,000	38,869	5.3
DANZIG, FREE CITY OF	305,000	17,248	5.7
DENMARK:			
Copenhagen	790,000	136,528	17.3
FINLAND:			
Helsingsfors	234,000	31,180	13.3
FRANCE:			
Bordeaux	264,000	16,207	6.1
Lille	208,000	14,301	6.9
Lyons	588,000	27,435	4.7
Marseilles	672,000	24,140	3.6
Paris	2,955,000	370,308	12.5
GERMANY:			
Berlin	4,330,000	515,175	11.9
Breslau	613,000	42,779	7.0
Cologne	725,000	68,967	9.5
Dresden	630,000	62,393	9.9
Dortmund	535,000	24,756	4.6
Düsseldorf	478,000	46,281	9.7
Essen	645,000	29,291	4.5
Frankfort-on-Main	623,000	65,606	10.5
Hamburg-Altona	1,590,000	173,828	10.9
Hannover	442,000	37,826	8.6
Leipzig	675,000	69,985	10.4
Munich	725,000	75,621	10.4
Nuremburg	494,000	36,924	7.5
Stuttgart	420,000	47,042	11.2
GREAT BRITAIN AND NORTHERN IRELAND (March 31, 1930):			
Belfast	420,000	15,138	3.6
Birmingham	1,115,000	49,805	4.5
Bradford	330,000	17,363	5.3
Bristol	410,000	17,933	4.4
Edinburgh	440,000	27,038	6.1
Glasgow	1,170,000	54,653	4.7
Hull	353,000	16,424	4.7
Leeds	505,000	20,952	4.1
Liverpool	1,165,000	55,091	4.7
London	7,740,000	675,783	8.7
Manchester	1,100,000	59,998	5.5
Newcastle	480,000	18,363	3.8
Nottingham	305,000	14,812	4.9
Portsmouth	290,000	6,993	2.4
Sheffield	515,000	18,049	3.5
Stoke-on-Trent	300,000	6,578	2.2

TELEPHONE DEVELOPMENT OF LARGE CITIES (Concluded)

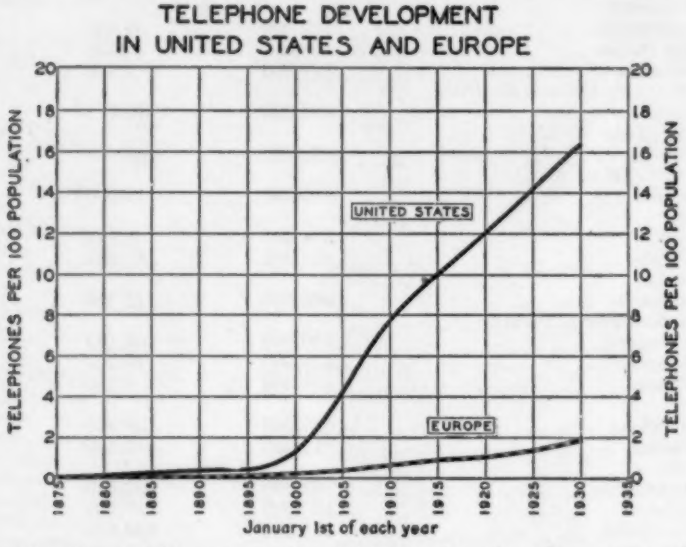
January 1, 1930

Country and City (or Exchange Area)	Estimated Population (City or Exchange Area)	Number of Telephones	Telephones per 100 Population
HUNGARY:			
Budapest	990,000	60,539	6.1
Szeged	127,000	2,560	2.0
IRISH FREE STATE (March 31, 1930):			
Dublin	396,000	15,350	3.9
ITALY:			
Genoa	628,000	22,516	3.6
Milan*	965,000	65,000	6.7
Rome	950,000	40,393	4.3
JAPAN (March 31, 1930):			
Kobe	755,000	28,938	3.8
Kyoto	755,000	33,439	4.4
Nagoya	905,000	27,834	3.1
Osaka	2,409,000	96,044	4.0
Tokio	2,295,000	136,546	6.0
LATVIA (March 31, 1930):			
Riga	378,000	15,745	4.2
MEXICO:			
Mexico City	950,000	47,165	5.0
NETHERLANDS:			
Amsterdam	749,000	47,048	6.3
The Hague	466,000	39,846	8.6
Rotterdam	597,000	40,158	6.7
NEW ZEALAND (March 31, 1930):			
Auckland	198,000	20,558	10.4
NORWAY (June 30, 1929):			
Oslo	250,000	45,353	18.1
PHILIPPINE ISLANDS:			
Manila	370,000	16,000*	4.3
POLAND:			
Lodz	824,000	11,912	1.4
Warsaw	1,109,000	52,426	4.7
ROUMANIA:			
Bucharest	800,000	15,280	1.9
RUSSIA (October 1, 1929):			
Leningrad	1,840,000	63,104	3.4
Moscow	2,420,000	70,247	2.9
Odessa	435,000	4,886	1.1
SPAIN:			
Barcelona	845,000	32,848	3.9
Madrid	814,000	35,320	4.3
SWEDEN:			
Gothenburg	242,000	35,376	14.6
Malmö	120,000	17,454	14.5
Stockholm	415,000	126,529	30.5
SWITZERLAND:			
Basel	146,000	20,629	14.1
Berne	112,000	17,191	15.3
Geneva	131,000	20,132	15.4
Zurich	222,000	37,864	17.1
UNITED STATES:†			
New York	6,898,600	1,811,410	26.3
Chicago	3,360,000	987,891	29.4
Los Angeles	1,270,000	383,979	30.2
Total of the 8 cities with over 1,000,000 population	19,302,800	4,898,715	25.4
Pittsburgh	976,200	229,135	23.5
Milwaukee	708,100	155,209	21.9
San Francisco	642,300	262,019	40.8
Washington	500,000	163,343	32.7
Total of the 10 cities with 500,000 to 1,000,000 population	6,824,400	1,585,578	23.2
Minneapolis	487,700	131,907	27.0
Seattle	397,500	124,504	31.3
Denver	287,100	89,756	31.3
Omaha	226,200	65,150	28.8
Total of the 32 cities with 200,000 to 500,000 population	9,649,400	2,090,988	21.7
Total of the 50 cities with more than 200,000 population	35,776,600	8,575,281	24.0

* Partly estimated.

† There are shown, for purposes of comparison with cities in other countries, the total development of all cities in the United States in certain population groups and the development of certain representative cities within each of such groups.

in Large Cities." London, for example, had 675,783 telephones on March 31, 1930, constituting about 36 per cent of all the telephones in Great Britain. Paris, with 370,308 telephones, had 35 per cent of all the instruments in France. The four principal cities of Berlin, Hamburg-Altona, Leipzig and Munich had about one-fourth of all the telephones in Germany. On the other hand, New York, with 1,811,410 telephones, had about 9 per cent, and Chicago, with 987,891 telephones, had less than 5 per cent of all the telephones in the United States. Eleven American cities with populations of over 200,000 are



shown in the table, none of which had a development of less than 21.9 telephones per 100 population. All cities in the United States with a population of 200,000 or more had an average development of 24 telephones for each 100 inhabitants. This figure is all the more impressive when it is considered that, excluding Sweden and Canada, no foreign country has any large city in which the development is as high as 20 telephones per 100 population.

The comparatively high telephone development of the large American cities is further emphasized by the chart, "Tele-

phones per 100 Population of Large Cities." In this chart San Francisco heads the list, with 40.8 telephones per 100 population, followed by Washington (32.7), Denver (31.3), and Seattle (31.3). Stockholm, by far the best developed of the larger European cities, had 30.5 telephones per 100 population, and ranks fifth. Paris is nineteenth, Berlin twentieth, and London twenty-seventh, with developments of 12.5, 11.9 and 8.7 telephones per 100 population, respectively. Of the first ten cities shown on the chart, eight are in the United States.

COUNTRIES REACHED BY TELEPHONE FROM THE UNITED STATES

The chart, "Countries Reached by Telephone from the United States," shows that on April 6, 1931, thirty-one countries could be reached by telephone from any Bell System instrument. In fact, on that date any Bell System telephone could be connected to any one of 12,600,000 telephones outside the United States. Adding these to the telephones connected to the Bell System in the United States, we have a total of 32,600,000 instruments available to Bell System subscribers, or 91.5 per cent of the estimated present total number of telephones in the world.

Some Auxiliary Services and Facilities of the Bell System

THE primary service of telephone communication rendered by the Bell System is so well known that its extent and efficiency are rather taken for granted by the American public. But there are ramifications of Bell System service that are not so familiar, and they include some highly interesting and useful auxiliary and by-product services of one kind or another. These fall naturally into two classes: first, those offered by Bell Operating Companies as refinements and adaptations of telephone service to meet the needs of particular situations and to increase the usefulness of the services; and, second, those facilities developed by the Bell Telephone Laboratories, Inc., and made available through the Western Electric Company and its subsidiary, Electrical Research Products, Inc., which afford services independent of and distinct from the telephone system proper.

The first class of auxiliary services has been developed by Bell System engineers to enable the operating companies to offer a flexible service adapted to individual personal or business needs. The objective is to develop new services and new adaptations of existing service and then show the public how these services can be advantageously utilized. For no matter how complete a service is offered by the telephone company and no matter how efficiently it is operated, the service, *from the telephone user's standpoint,* is not at its best unless his telephone arrangements meet his requirements as to comfort, convenience, and efficiency.

The hand-set telephone, which in addition to its attractive appearance can be manipulated with one hand, is an example of how telephone service may be made of maximum convenience to the user. In addition to the familiar form of this in-

strument, it is also available in a hang-up type which may be installed unobtrusively at the side of a desk or elsewhere. This is especially appreciated by architects, engineers, builders and others who like to keep the tops of their desks clear for spreading out large plans and drawings.

Residence Telephone Service

The simplest arrangement of telephone facilities, of course, either residence or business, consists of one line to the central office with one telephone on the subscriber's premises. In addition, one or more extension telephones may be provided, connected with the same line. This makes it possible to provide telephone comfort and convenience in the home by installing one telephone downstairs and another upstairs, or one in the living room, one in a bedroom and another in the kitchen, etc. A great many people in comfortable circumstances now provide themselves with every modern facility for comfort and convenience in the way of telephone equipment as well as other electrical appliances in their homes. The Bell System has for some years been actively calling attention to the possibilities of really adequate telephone service in the home, for saving time and effort, and fitting in with the modern way of life. This is directly in the interest of rendering a service that shall be thoroughly satisfactory to the user. The reduced rates for evening and night long distance calls, the arrangements for reversing the charges, etc., all help to make telephone service as useful as possible for personal as well as business messages.

In large residences, adequate telephone service may include the provision of two or more lines to the central office, one or two for the social uses of the household and the other primarily for the use of the servants. Of course, there is at least one telephone on each line and, in addition, extensions may be provided on either one or both of the lines as may be desired.

Such a lay-out is extremely flexible and can be so arranged as to meet practically any service need. Generally speaking,

the telephone companies are in a position to provide any one of many different wiring plan arrangements for use in residences. Suppose, for example, that telephones are installed in the living-room, in the kitchen and in an upstairs bedroom. There are a good many different things that can be done with such a lay-out. If one of the family wishes to talk from the bedroom to the maid in the kitchen, the facilities can be arranged so that that can be done. Or if the subscriber is talking over the telephone in the living-room or bedroom, he can cut off the kitchen telephone. Different numbers may be assigned to the kitchen telephone and the living-room telephone, if the subscriber wishes, so as to separate incoming calls for the family from those for the servants. And even with such an arrangement, it can still be made possible for the maid to answer in the kitchen when someone is wanted on the living-room telephone. She can even hold the call on one line while she talks (over another line, but from the same instrument) to one of the family—who may be upstairs, for instance—and tells him he is wanted on the telephone. The person who has called up, of course, does not hear that conversation. And from any telephone one can call people to any other by bells, buzzers, or electric lamps, which the telephone company can install practically anywhere about the premises.

These arrangements are available irrespective of whether the subscriber is served by a dial or a manual central office. Then there is also apparatus for intercommunication of larger capacity which is still compact and unobtrusive. For instance, a set of buttons in the base of the telephone is all that the user needs to see of the apparatus that makes possible intercommunication among any number of telephones up to fifteen. The rest of the equipment is in a cabinet which may be relegated to some out-of-the-way corner. And those little push buttons in the base of a neat hand telephone have been designed with an eye to good appearance as well as convenience. Such an intercommunicating system is useful for lawyers, doctors and

small business offices as well as for large residences and private estates. A system of this kind was described in detail in the BELL TELEPHONE QUARTERLY for October, 1930.

PORTABLE TELEPHONES

In most homes there are certain rooms that are not continuously occupied. The guest-room, for one. The dining-room, for another. In some houses a sun-porch in summer or a billiard-room in winter represents additional space which is in use at certain times, but not continuously. Guests appreciate the extra touch of thoughtful hospitality implied in having a telephone in the guest-room. And it is convenient to be able to take a call on the sun-porch in summer. It is not necessary to keep a telephone in the guest-room or dining-room or sun-porch when they are unoccupied, however. "Jacks" or outlets can be installed in these locations and a portable telephone, equipped with a cord and plug, can be carried from room to room and plugged into a convenient jack for making or answering calls.

Some restaurants provide this jack and portable telephone equipment so that patrons can have a telephone brought to their table, if they wish. Certain progressive barber shops have found that customers appreciate being able to telephone direct from the barber's chair whenever they want to. There is a place for such equipment in "beauty shops," too, as women enjoy being able to chat with their friends by telephone, particularly while undergoing a permanent wave.

HEAD RECEIVERS AND DEAF SETS

Sometimes the telephone companies' customers have certain particular problems to be solved in connection with their telephone service, and the companies arrange to meet these individual needs. Occasionally a customer is hard of hearing and finds difficulty in using the telephone. For this situation there is available a telephone equipped with an amplifying unit. A

key is provided to connect and disconnect the amplifier from the telephone circuit, and the volume of amplified speech can be made louder or softer at will.

Private Branch Exchanges

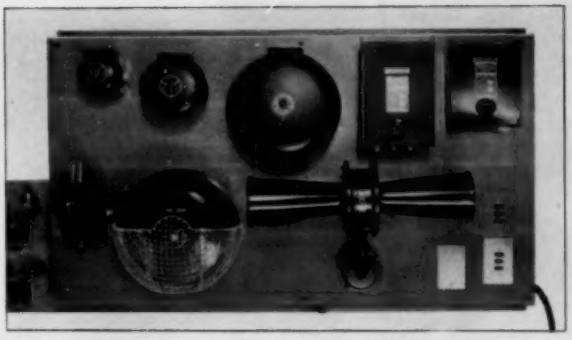
The telephone services above described for residence purposes are also available for business use. Of course, large business establishments have more telephones than even the most elaborate residences and many business private branch exchanges are installed on a subscriber's premises by which one or more employees of the subscriber can switch incoming or outgoing calls among as well as interconnect the various telephones in the subscriber's establishment. These range all the way from the small key (cordless) switchboards to the large boards installed in hotels, banks, department stores, newspaper offices, etc. The little cordless boards usually provide for seven telephones and three trunk lines to the central offices. The larger manual boards may be either non-multiple, for use in locations where three or more trunks and seven or more telephones are required; or multiple, for use where more than two private branch exchange operators must have access to all lines.

In addition, there are dial systems where the subscriber dials his intercommunicating and outgoing calls, attendant service being provided for incoming calls.

Order Receiving Equipment

There has been an extensive development of late years in shopping by telephone, and department stores have found that it pays them well to provide up-to-date equipment for the prompt handling of orders that are telephoned in. Newspapers have a similar problem in taking care of classified advertisements by telephone. To meet this need, equipment has been developed by the Bell System that is designed for the reception of orders with a maximum of convenience and speed, and permits of an efficient distribution of incoming calls among

Hand Telephone, Hang-up Type.



Gongs, Horns, etc., Code Calling Service.

Intercommunicating System Handset.

Portable Telephone.

Telephone for the Hard of Hearing.

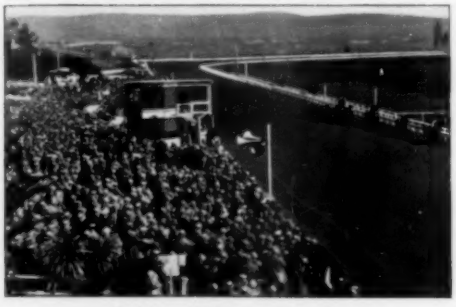
Dial Private Branch Exchange, Attendant's Turret.

Taking Orders by Telephone.

Cord Private Branch Exchange, with Code Calling Equipment.

Teletypewriter and Control Board.

Teletypewriter.



Public Address System.

a group of attendants equipped with head receivers. The equipment consists of a small cabinet or turret which is mounted on a suitable table, and as the calls come in they are answered by a group of attendants who sit at the table. These installations may be provided for any number of attendants, depending upon the amount of business to be handled. They may be non-multiple or multiple as desired. Equipment may be operated in connection with a private branch exchange, or may be connected directly to the central office, or, if desired, it may be connected directly to the central office with lines running also to the private branch exchange switchboard.

Code Calling Equipment

For other special needs there are other forms of specialized equipment available. For example, there is the case of the superintendent of a factory with one or several buildings covering acres of floor-space. He has an office on the premises, but he spends a large part of his time keeping in personal touch with operations here, there and everywhere throughout the factory. Important telephone calls come in when he is not in his office, but is known to be somewhere around the plant. To meet that situation there is available what is known as "code calling equipment." This is an arrangement of apparatus whereby bells or horns at various locations throughout the premises may be operated to sound code signals and thus summon persons who are not at their regular telephone stations to step to the nearest telephone and from there answer an incoming call. Each person is assigned his own particular code call. Occasionally, people having large residence establishments or estates ask the telephone company to install code calling equipment so that when the owner happens to be in the garage, or down at the boathouse, or out at the tennis court, he can be easily called when he is wanted on the telephone.

Outdoor Set

Still further convenience is afforded by special outdoor telephones in weatherproof boxes which can be put up at tennis courts or golf links, or in similar locations. That is rather an incidental use of this equipment, however. The outdoor telephone is chiefly used for police call boxes and for taxicab stands and other businesses at outdoor locations. Sometimes it is placed at railroad stations and like localities with an arrangement which enables a prospective customer to call a taxi and have the call charged to the taxi company.

Conference Equipment, Etc.

Another case calling for special telephone equipment is that of the business executive who wishes to be able to confer with a number of his associates quickly and easily, without taking them away from their desks. He can do this by means of what is called "conference equipment." This provides means by which telephone conferences may be held by several persons simultaneously, everything that is said by any of the conferees being audible to all.

Then there is the case of the business or professional man who wishes to have his secretary answer his telephone calls when he is out, but does not want to have it possible for her to listen in while he is talking. The telephone company can arrange his telephone equipment to meet those requirements precisely.

Private Line and Foreign Exchange Services

Some business concerns want a private telephone line between office and factory, for example, not connected to the general telephone system at all. The telephone company can supply that. Or, again, if they wish direct lines connecting two or more private branch exchanges, that equipment also can be furnished.

Another problem is that of a subscriber who desires to make it possible for people in another exchange area to call him up

by telephone without having to pay a toll charge for the calls. There are two different ways in which this can be done. A store may have a special telephone number for its order department, and may arrange with the telephone company to have the charges reversed on calls to that number. Or a subscriber may have "foreign exchange service." This arrangement is exchange service furnished from a central office in an exchange area other than that in which the subscriber is located. For example, a subscriber in Boston may have a telephone number in New York. This has proved to be a very effective method for building up out-of-town business, especially when used in connection with advertising campaigns, in newspapers and direct mail, urging customers to place their orders by telephone, and pointing out that they can do so without payment of toll charges.

Practically all of these services and devices are adaptations of regular telephone service in one way or another. But suppose a company has an office in New York and a factory in Detroit, and wants to arrange for the use of the telephone all the time without paying for each call separately—or for the use of the telephone every day at a specified time—say from two to three o'clock, or any other period desired. Arrangements for such services can be made with the telephone company by contract.

Another form of service provides for manually operated telegraph service. The telephone company provides the line and the equipment, and the subscriber provides the operators on either end. This is a service extensively utilized by brokerage houses and newspapers.

Teletypewriter Service

In this connection the teletypewriter is coming into constantly greater use. This device may be described as two or more typewriters at separated points, whether in the same building or thousands of miles apart, connected by wires and

electrical apparatus in such a way that anything typed at the sending machine will come out in typewritten copy at the receiving machines, either in page or tape form. The telephone company provides and maintains the necessary connecting channels and associated apparatus. The teletypewriter makes it possible to transmit simultaneous messages to any one or all of a number of receiving points from a single transmitting station. The teletypewriter is being widely used by brokerage houses and newspapers, and for communication between airports and the like. It is an invaluable means of quick communication between the police departments of neighboring communities, especially for sending out descriptions of "wanted" persons or stolen cars. For a detailed discussion of teletypewriter service and its present day uses, see the BELL TELEPHONE QUARTERLY for April, 1931.

PROGRAM TRANSMISSION SERVICE

The telephone companies also play a large and very essential part in radio broadcasting. They provide local or inter-city circuits for the purpose of transmitting programs from various sources to broadcasting stations. Chain broadcasting, in fact, is made possible by the utilization of thousands of miles of telephone circuits. On one occasion 106 broadcasting stations were linked up by 25,300 miles of telephone wire for the simultaneous broadcasting of a single speech. At another time 121 stations were joined by telephone wires for simultaneous broadcasting. An article on this service was published in the BELL TELEPHONE QUARTERLY for April, 1931.

TELEPHOTOGRAPH SERVICE

Another auxiliary service is the transmission of photographs by wire. Telephoto transmitting and receiving apparatus is maintained at eight cities, Boston, New York, Atlanta, Cleveland, Chicago, St. Louis, Los Angeles and San Francisco. News pictures are frequently sent in this way, and by distributing them by air mail from the cities reached by telephoto

service, it is possible to send a photograph to newspapers all over the country within a very short time. The service is also useful for the transmission of thumb prints and Rogues' Gallery photographs for police identification of criminals, for the transmission of pictures of new styles as soon as they are received at New York, and for transmitting proofs of advertisements and the like. Advertisements, particularly those to be released simultaneously on the Atlantic and Pacific Coasts, can be transmitted in this way without risk of error, since the photograph received, of course, is an exact duplicate of the photograph transmitted.

Telephone Directories

Then there are the telephone directories. The telephone companies try to make them as useful as possible to telephone users. A telephone subscriber can get directories for other areas if he needs them, and in many localities there are available, at a reasonable charge, directories listing the names and telephone numbers of subscribers numerically by street address.

If a subscriber wishes he can arrange under certain conditions to have several names listed in the telephone directory in addition to the listing that goes with every telephone. Or a firm, say Smith & Jones, may have its firm name and the names of individuals in the firm listed separately with its business telephone number. In addition, a notice can be put in the directory telling what number to call if the regularly listed number does not answer. An adaptation of this is the night listing, which tells what number to call during certain hours or after certain hours. These two services are especially useful for doctors, but there are others, too, who find them of advantage.

Then there are the classified listings and display advertisements which enable business telephone subscribers to be represented in the classified telephone directories under the heading of the product or service they have to sell. A subscriber may

purchase as many such listings or advertisements as he has products to advertise.

"Where to Buy It" Service

Within the last few years the Bell System has introduced Trade Mark Headings in the classified telephone directories. These consist of the name of a trade marked product or service, a few words descriptive of it, and the trade mark symbol, under which are placed the names of dealers in the product or service. If one is looking for a Ford Service Station, or a dealer in Sherwin-Williams Paints, or Whitman's candy, he can find them by turning to the Trade Mark Heading in the classified telephone directory. The Service is of great value to dealers also in steering to their stores people who have been "sold" by the advertising of the manufacturer of the trade marked product. In this way it links up national advertising with local distribution, to the mutual advantage of the manufacturer, dealer and purchaser. Further information on this subject may be found in the Bell Telephone Quarterly for July, 1930.

Services for Salesmen

The use of toll and long distance telephone service in selling by representatives of manufacturers and retailers has increased greatly in recent years. Like other uses of long distance service, it has no doubt been stimulated by the successive reductions in long distance telephone rates in 1926, 1927, 1929 and 1930 which represent a saving to the public of about $20,000,000 a year. To assist sales representatives in getting the utmost value out of their use of the telephone, the Bell System has worked out plans for "Key-town" selling, whereby the salesman visits the key-towns in his territory and canvasses the surrounding areas by telephone. Key-town maps, obtainable from the telephone companies, show the location of key-towns and the rates for calls to nearby points.

A further refinement of the Key-town plan is the "Skip-stop" plan,—the salesman visiting alternate towns on his route and covering intermediate towns by telephone. On the next trip he visits the towns he covered by telephone before and telephones to customers on whom he called personally on the previous trip.

At many points customers' rooms are provided at the telephone company business offices from which calls may be put through with great comfort. If the salesman's firm has provided him with a telephone identification card under the Bell System credit plan, his calls may be charged to the account of the home office of his firm. These plans for facilitating telephone selling by wholesalers and manufacturers were fully described in the BELL TELEPHONE QUARTERLY for January, 1929.

WESTERN ELECTRIC FACILITIES

Of the facilities outside of the telephone service developed by Bell System engineers and made available through the Western Electric Company and its subsidiary, Electrical Research Products, Inc., the most famous is the talking motion picture equipment which has revolutionized the movie industry. Another is the new service for measuring noise which is described elsewhere in this issue of the BELL TELEPHONE QUARTERLY.

The Public Address System enables speakers to address large audiences indoors or outside without straining their voices. It is used at race-tracks, stadiums, convention halls, overflow meetings, newspaper bulletin boards, etc., and for increasing the audibility of music at amusement parks and ball-rooms. There is also a Music Reproducer which magnifies the sound of phonograph records for use in restaurants and other places of amusement.

The Western Electric Hard-of-Hearing System is a device with headsets installed in movie houses, churches and other auditoriums to enable those with defective hearing to enjoy the

talkies, church services, speeches, music, etc. The volume of sound delivered is controlled individually by each user.

There is also an Electrical Stethoscope which magnifies the sound of heart-beats, thereby facilitating diagnosis in cases of heart-disease.

More directly related to telephone communication are the two-way radio telephone systems which the Western Electric Company manufactures for use between ship and shore and between aircraft in flight and ground stations. The Marine Radio Telephone Equipment is particularly useful for harbor craft such as tug-boats, ferry-boats, lighters, municipal fire-boats and pilot-boats. It is also of value for fishing-craft.

The Aviation Communication Equipment is of two types: a low frequency system for receiving radio beacon signals and weather reports, and a two-way high frequency radio telephone system which permits the plane to keep in constant touch with other planes and with ground stations. It is an invaluable aid to safe flying, as landing instructions and weather reports can be received *en route*.

The Western Electric Company manufactures a wide range of radio telephone equipment and has provided a majority of the large broadcasting stations in the United States.

It has likewise applied its telephone developments in the field of electrical recording to the making of electrical transcriptions for radio use, and it supplies broadcasting stations with the equipment to put on these so-called "spot broadcasting" programs, which are used by advertisers who desire to reach the territory covered by an individual station or a group of such stations.

The Western Electric Company also manufactures for the use of railroads, oil companies, mines and others, switchboard and other telephone apparatus and communication equipment. In addition, it provides the high speed submarine telegraph cables used in trans-Atlantic and trans-Pacific wire communication.

A Unifying Objective

All these various services and devices that the Bell System has developed, whether they are directly a part of the telephone service or by-products of it, have been worked out by Bell engineers for the service of the public. They are the products of the large numbers of highly trained specialists who are constantly planning how to make the telephone service more useful, and how to develop new phases of service. Diverse as are the results of this research it has a unifying objective: to increase human knowledge of electrical communication and to turn the forces of nature to the service of mankind. Much has been achieved and more will certainly be accomplished in the future. Nothing has been said, for example, of Television because it is still in the experimental stage and Bell System engineers are unwilling to predict what its future sphere of service may be.

Richard Storrs Coe

The Development of the Microphone

(Presented at fifth meeting of the Acoustical Society of America, Camden, N. J., May 5th, 1931, as part of a symposium on microphones.)

THE invention of the telephone by Alexander Graham Bell accomplished a result which has revolutionized our means of communication. Like most similarly broad and fundamental inventions, it was based on a clear and thorough understanding of scientific work which had preceded it. Viewed after the lapse of 55 years it is clear that the development of human knowledge was very definitely leading up to this great invention for a period extending over several decades. It is of interest to note a few of the more outstanding steps. In 1837 in Salem, Mass., Dr. Page observed that sounds were emitted by a magnet if its magnetism was suddenly changed. He studied the effect and developed several different means of producing these sounds; for example, rapidly rotating a horseshoe magnet in a strong magnetic field. In this way he obtained musical tones and termed the effect "galvanic music." The results were published[1] and broadly known among scientific workers. In 1845, Sullivan observed that currents of electricity were generated by the vibration of a wire composed partly of one metal and partly of another.[2] Bourseuil[3] in 1854 described as a "telephone" a device "using a make and break" transmitter. In his written description he apparently considered the smooth or continuous modulation or variation of current unnecessary for the transmission of sounds. Satisfied with the written description he seems to have made no great effort to reduce his ideas to practical operation.

[1] Silliman's Journal, 1837, page 396.
[2] Phil. Mag., 1845, page 261.
[3] The Didaskalia, Frankfort/M, Sept. 28, 1854; Du Moncel, Applications de l'Electricité, 1854; U. S. Supreme Court Reports, Vol. 126 (1887).

Philip Reis,[4] a teacher of Physics in Garnier's Institute at Friedrichsdorf, Germany, in 1861 constructed models based on much the same fundamental ideas as those disclosed by Page and Bourseuil and produced what he called a "telephone." The receiver was operated on the magneto-striction principle and consisted of a knitting needle surrounded by a coil of wire. It was mounted on a sounding board. The transmitter was a platinum make-and-break contact operated by a membrane (Fig. 1). This transmitter was apparently quite sharply resonant and was operative only for rather continuous tones. Tones of different frequencies were transmitted, however, and it is reported that several tones were transmitted simultaneously. Reis never succeeded in transmitting articulate speech. With one of his transmitter models which was open on both sides of the diaphragm he used a baffle about 20 inches in diameter "to prevent interference between the front and back."

In 1863 Helmholtz published his classic work on acoustics.[5] This greatly extended the basic understanding on which subsequent developments proceeded.

In 1870 Varley discovered that sound may be emitted by a condenser.[6]

In 1874 Alexander Graham Bell, Professor of Vocal Physiology at Boston University, was busily engaged in the study of speech, hearing and telegraphy. He was interested in obtaining graphic records of sounds, and in discussing the problem with a friend, Dr. Clarence Blake, the suggestion was offered that a model consisting of an actual human ear might suffice. Dr. Blake prepared such a model which operated successfully and seems to have been of great aid to Dr. Bell. Telling of these experiments three years later he stated[7] "The stapes was removed and a stylus of hay about an inch in length was at-

[4] Prescott, The Electric Telephone p. 9 (Appleton & Co., 1879–'84–'90).

[5] Die Lehre von dem Tonempfindungen, 1st G. ed., 1863. Translation by Ellis, 1st English trans., 1875.

[6] Piérard, La Téléphonie, p. 20 (Desoer, Liége, 1894).

[7] Journal Society Telegraph Engineers, Oct. 1, 1877, p. 403.

tached to the end of the incus. Upon moistening the membrana tympani and the ossiculæ with a mixture of glycerine and water, the necessary mobility of the parts was obtained, and upon singing into the experimental artificial ear, the stylus of hay was thrown into vibration and tracings were obtained upon a surface of smoked glass passed rapidly underneath. While engaged in these experiments, I was struck with the remarkable disproportion in weight between the membrane and the bones that were vibrated by it. It occurred to me that if a membrane as thin as tissue paper could control the vibration of bones that were, compared to it, of immense size and weight, why should not a larger and thicker membrane be built to vibrate a piece of iron in front of an electromagnet." It seems certain that Professor Bell was possessed of a very clear understanding of his problem. There are numerous evidences of his broad and complete familiarity with the work of other scientific investigators and it appears that having developed new ideas on the characteristics of speech and what is needed to transmit and reproduce it electrically, he then proceeded with energy and enthusiasm to overcome the difficulties of reducing these ideas to practical operation. The conception of a "membrane speaking telephone" appears to have become complete in Bell's mind in substantially the form shown as figure 7 of his later patent,[8] in the summer of 1874 (Fig. 2).

On June 2, 1875, Bell heard a tuned reed receiver, with which he was experimenting in connection with his harmonic telegraph system, vibrate in response to the plucking of a somewhat similar tuned reed transmitter at the other end of the line (Fig. 3). The simple observation appears hardly more significant than similar observations of men who preceded Bell a number of years. Yet the phenomenon in his mind took on the greatest meaning. He immediately gave his assistant Watson instructions for the design of a structure which mounted a small drumhead of gold beater's skin over one of the vibrating reeds, joined

[8] Rhodes, Beginnings of Telephony (Harper & Bros., 1929).

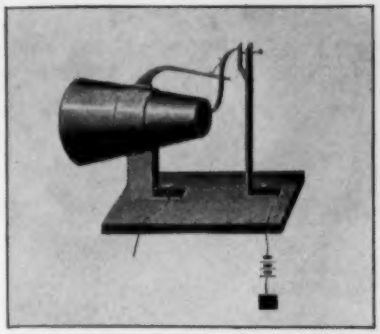


FIG. 1. Reis microphone. A make-and-break platinum contact microphone with which musical sounds but not speech were transmitted in 1861.

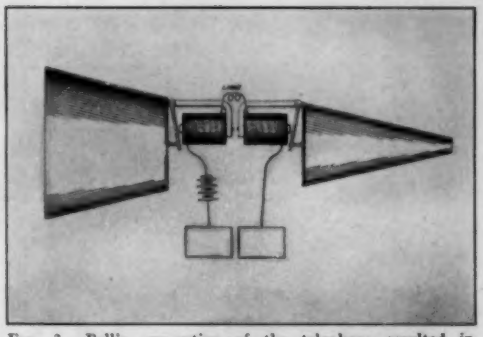


FIG. 2. Bell's conception of the telephone resulted in this sketch which was used in his first patent application of 1876.

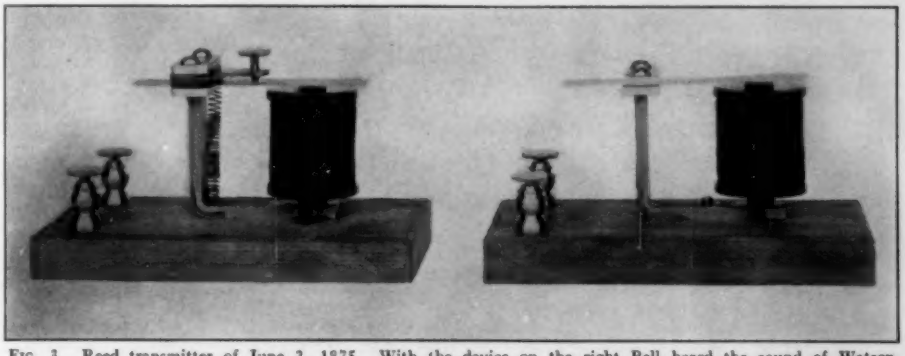


FIG. 3. Reed transmitter of June 2, 1875. With the device on the right Bell heard the sound of Watson plucking the reed of the device on the left with his finger.

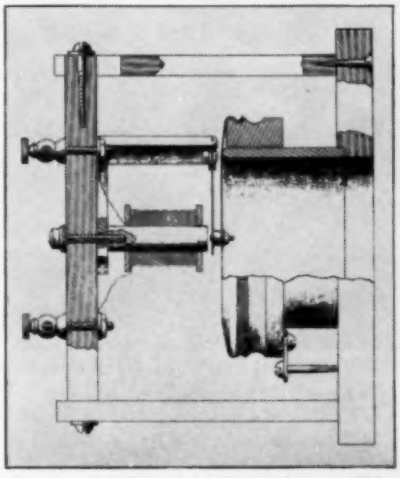


FIG. 4. "Gallows frame" transmitter. This is the instrument by which Bell transmitted the sound of his voice to Watson, June 3, 1875.

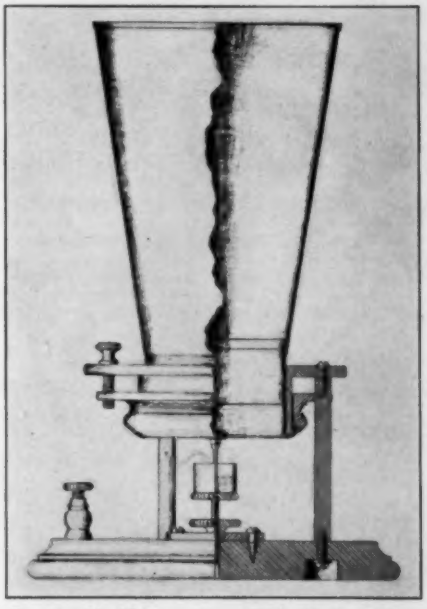


FIG. 5. Liquid transmitter. With this transmitter in March, 1877, Bell said "Mr. Watson come here, I want you."

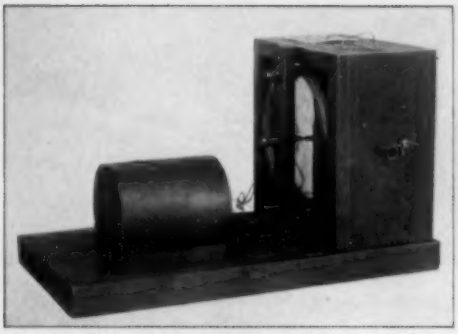


FIG. 6. Berliner invented this single contact microphone in 1877.

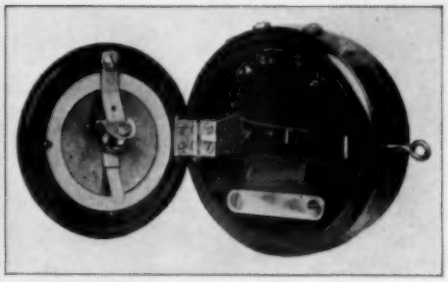


FIG. 7. This carbon to carbon single contact Berliner transmitter was brought out in 1879.

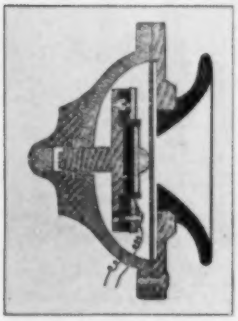


FIG. 8. The Edison transmitter used a solid disk of carbon as the variable resistance element.

FIG. 11. This Ader transmitter used 10 carbon pencils connected 5 in parallel, 2 in series.

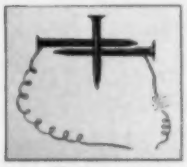


FIG. 9. Hughes nail microphone. Prof. Hughes in 1878 demonstrated the effects obtained with this simple but sensitive inertia type microphone.

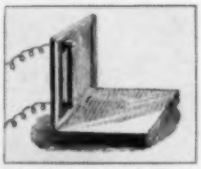


FIG. 10. Pencil Type microphone of carbon mounted on a sounding board. Demonstrated by Hughes in 1878.

FIG. 12. Music from the Paris opera was picked up by a series of Ader multiple carbon pencil microphones mounted in front of the foot lights.

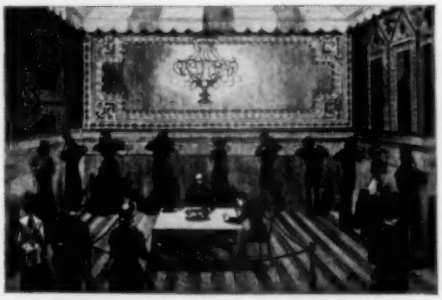


FIG. 13. Reception of music from the Paris opera by binaural system in 1881.

the center of the drumhead to the free end of the receiver spring or reed and arranged a mouthpiece over the drumhead to talk into. This model (Fig. 4) was prepared in record time by the enthusiastic Watson and was tested on the succeeding day, June 3. Watson reports distinctly hearing the tones of Bell's voice. He, however, reports with some sadness that his own voice was not as strong as Professor Bell's and therefore he could not make it heard. The principle, however, had been proven beyond doubt in Bell's mind and advance was sure. The difficulty was to devise more efficient or sensitive means.

Measurements have been made of the response of these early instruments. They show quite definitely that the first sounds transmitted must have been barely audible. Had the inventor not understood very clearly for what he was searching and what he expected to hear, these extremely faint sounds could hardly have attracted his attention.

Until recently the great demand has been for greater and greater transmitter output. Improvements in receiver efficiency raise the noise level with the level of speech whereas increased transmitter output means overriding the noise. As long as the transmitter merely converts the power of the voice itself, from acoustic to electrical form its output is, of course, necessarily very limited. The natural course has been to utilize in the design of a transmitter some principle or device in which the vibrations of the voice serve merely to control or modulate power supplied by some independent source, such as a battery; that is, the sound waves must be made to modulate a resistance through which a current is flowing in such a manner that the resultant current changes are a sufficiently accurate counterpart of the pressure changes in the air. Such a device should not and need not impose restrictions on the motion of the diaphragm used to pick up the motion from the air. It was to such a device that Bell turned in his next experiments. To a drum head of gold beater's skin in a horizontal position he attached a small platinum wire (Fig. 5). This barely made

contact with the surface of a small quantity of acidulated water in a conducting cup. Vibration of the diaphragm varied the depth and area of contact between the wire and the surface of the water and therefore the resistance between them. Such a model was constructed and successfully tested March 10, 1876. This was the first transmitter to transmit successfully a complete sentence "Mr. Watson, come here—I want you."

Bell's patent application was filed February 14, 1876, and granted March 7, 1876. Later in the same day (February 14th) Elisha Gray filed a caveat, or statement of intention to later file patent application, claiming the art of transmitting speech electrically. The claims of Bell to inventorship of the telephone were widely contested in the courts, during the twenty years following, Reis, Dolbear, Blake, Gray, Drawbaugh and others having been claimed to be the inventors. The ensuing litigation was most extensive and continued until 1896. During this time Bell's claims were exhaustively investigated and were finally validated by the United States Supreme Court.[9]

Following his first successful transmission of a complete sentence in 1876, Bell promptly described his invention in numerous public lectures and demonstrations in both the United States and England; on May 10, 1876, before the American Academy of Arts and Sciences in Boston,[10] at the Centennial Exposition in Philadelphia,[11] June, 1876, before the Society of Telegraph Engineers in London,[7] October, 1877, etc. As a result, numerous inventors appreciating the fundamental importance of the new discovery promptly attacked the problem. During the five succeeding years almost every conceivable means of converting sound into electricity was tried. In fact, the situation was well described by Preece in 1882:[12] "There

[9] U. S. Supreme Court Reports, Vol. 126, Oct. term, 1887.

[10] Proc. Am. Acad. of Arts and Sciences, Vol. 12 (new series, No. 4), May, 1876–May, 1877, pp. 1–10.

[11] Casson, "History of the Telephone," p. 35 (McClurg & Co., 1913).

[7] Loc. cit.

[12] Prescott, loc. cit., p. 361 (1890).

is nothing more marvellous than the wonderful versatility of this power which electricity possesses of making everything produce speech. Now that we know what electricity can do, the difficulty appears to be not so much how to make the apparatus talk, but how to prevent it from speaking."

In 1877, Emile Berliner in Washington observed that the resistance of a loose contact varied with pressure, and constructed successful working models utilizing this principle.[13] The Berliner device was much like one used by Du Moncel in 1856.[14] The difference apparently was almost wholly one of understanding and resultant application and development. His first models used metallic contacts (Fig. 6) but these were later replaced by carbon (Fig. 7). Berliner's models were much more efficient than previous designs but their performance was extremely erratic, they could not be used in various positions, would carry but little direct current and would not maintain their adjustment. They were, nevertheless, developed to such a point that they were in considerable practical use.

In 1877, Edison[15] patented a transmitter of a variable resistance amplifying type in which the resistance element was a "button" of solid carbon or plumbago. This device (Fig. 8) gave quite good quality and was somewhat less erratic than previous designs. It was however relatively insensitive. He experimented with a wide variety of materials including "hyperoxide of lead, iodide of copper, black oxide of manganese, graphite, gas carbon, platinum black, finely divided metals including osmium, ruthenium, silicon, boron, iridium and platinum, in fact all the conducting oxides, sulphides, iodides, fibre coated with metals by chemical means and pressed into buttons, liquids in porous buttons of finely divided non-conducting material," but better than any of these he found was a button of lamp-black compressed into a solid disc by the application of

[13] Caveat filed in U. S. Patent Office, Apr. 14, 1877.
[14] Exposé des Applications de l'Electricité (1857).
[15] British Patent No. 2909, July 30, 1877; U. S. Patent No. 474,230, May 3, 1892 (Application filed Apr. 27, 1877).

several thousand pounds' pressure.[16] Due to the need of greater output and in order to transmit currents over greater distances, he devised and patented a combination of a telephone receiver and such a button, thus providing an amplifier or repeater. In some of Edison's transmitter models he interposed soft rubber between the diaphragm and the button in order, as he explained, "to damp the natural motion of the diaphragm. Interference with articulation which the prolonged vibration of the metal tends to produce in consequence of its elasticity is thus prevented and the sound comes out clear and distinct." This use of rubber undoubtedly added some damping. It probably also served to couple the diaphragm and its relatively low mechanical impedance and large amplitude to the high impedance, low amplitude or high pressure carbon button and very likely increased the efficiency and decreased the nonlinear distortion by keeping the vibrations at the carbon within the narrow amplitude range within which its resistance change is substantially proportional to the displacement of the electrode. In other words, it served to couple an "amplitude" system to a "pressure" system. Edison later concluded that the carbon responded to changes in "pressure" only and not to "amplitude."

The Edison microphone was rugged, would operate in any position and gave rather better quality than its predecessors. It was however quite insensitive. The resistance was about 4 ohms, and it was operated from a low voltage source of approximately 1½ volts.

In May, 1878, Hughes in London published[17] an account of experiments with loose contacts between different materials. He described how a microphone may be made of three nails (Fig. 9), one resting on the other two, the loose contacts being highly sensitive to any vibrations either of their support or of the air. Following these ideas, models of sharpened pencils of

[16] Prescott, loc. cit., p. 124.
[17] Proc. Royal Soc., XXVII, 366; Phil. Mag., 5th series, Vol. VI, p. 44.

carbon mounted on a vibrating support were developed (Fig. 10). These inertia transmitters were extremely sensitive and were termed "microphones." The forces at the contacts were due to the mass reactance of the loose element.

The term "microphone" was revived by Hughes at this time. The term was apparently coined and first used by Wheatstone in 1827[18] for a purely acoustic device which he developed to amplify weak sounds. The term was for years used only to refer to sensitive loose contacts of the type used by Hughes and was not applied to telephone transmitters generally. More recently, the term "microphone" has been used, particularly in radio broadcast, public address and sound picture work, for any device which converts from sound to corresponding electric currents. In view of this usage the term microphone will be used here as synonymous with transmitter, particularly for applications other than those in the usual telephone system.

The Hughes microphone consisting of a carbon pencil sharpened at both ends and resting loosely in carbon supports received considerable development and commercial use in Europe, particularly in France where Ader and several contemporaries developed the multiple carbon pencil microphone (Fig. 11). This usually consisted of 6 to 12 such pencils connected electrically in series multiple. They were usually mounted on a rectangular sounding board of thin well-seasoned pine or spruce. These devices were quite successful and were to be found in commercial telephone systems until quite recently. The Hughes and later the Ader microphones were very sensitive but also quite erratic in their behavior. They were very sensitive to mechanical vibrations.

The Ader microphone was used at an early date for picking up musical programs. Considering recent developments in work of this type, it is of interest to quote an account published by Prescott in 1884:

"One of the most popular attractions at the Paris Electrical

[18] Wheatstone, "Scientific Papers," p. 32.

Exhibition of 1881 was the demonstration of the marvellous powers of the Bell telephone, by its transmission of the singing on the stage and the music in the orchestra of the Grand Opera. This demonstration was given nightly, . . . eighty telephones were constantly at work at the same time, the communication being shifted at short intervals to another set of eighty similar instruments in two other rooms."

"The transmitters were microphones of the Ader system, placed in front of the opera stage, close to the footlights and behind them." (Fig. 12.)

"A new acoustic effect was discovered by Mr. Ader, and applied for the first time in the telephonic transmission at the Electrical Exhibition. In listening with both ears at the two telephones, the sound took on a special character of relief and localization which a single receiver could not produce. It is a common experience that, in listening at a telephone, it is practically impossible to have even a vague idea of the distance at which the person at the other end of the line appears to be. In this case there was nothing of the kind. As soon as the experiment commenced the singers placed themselves, in the mind of the listener, at a fixed distance, some to the right and others to the left. It was easy to follow their movements, and to indicate exactly, each time that they changed their position, the imaginary distance at which they appeared to be."

Each person was provided with two telephone receivers (Fig. 13) which received their impressions from two distinct microphones placed a certain distance apart. Prescott explained the effect purely on a relative loudness basis not as being in any way related to phase differences.

In 1878, Francis Blake [19] in this country designed a telephone transmitter in which a block of hard carbon was supported on a rather stiff spring (Fig. 14). Between this and the vibrating diaphragm was interposed a small bead of platinum on a light

[19] U. S. Patents Nos. 250,126 to 250,129, Nov. 29, 1881; British Patent No. 229, Jan. 20, 1879.
Rhodes, loc. cit., p. 79.

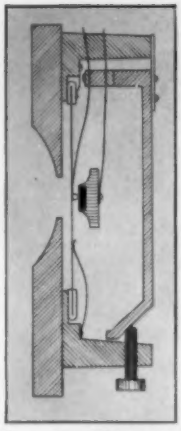


FIG. 14. This cross-section of an early Blake transmitter shows it to be of the inertia type.

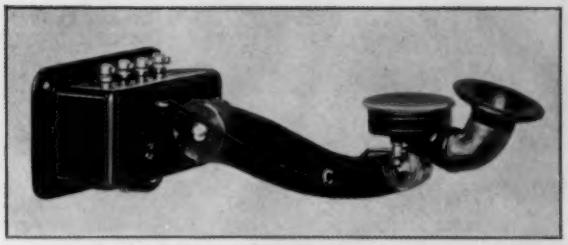


FIG. 15. The "long distance" transmitter of 1886, a development of Hunnings' transmitter, used Edison granular carbon in a horizontal cell.

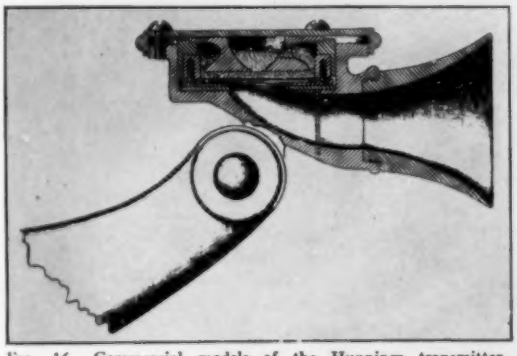


FIG. 16. Commercial models of the Hunnings transmitter were used in a horizontal position with the carbon resting on the diaphragm. The fixed electrode projected well into the granular mass.

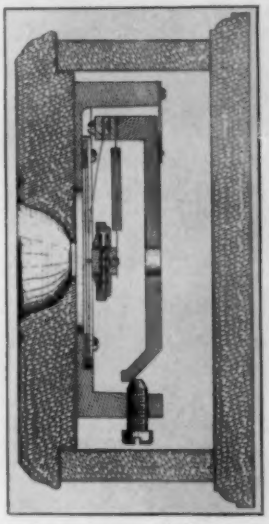


FIG. 17. The Blake type transmitter was later developed to this form using a button containing granular carbon.

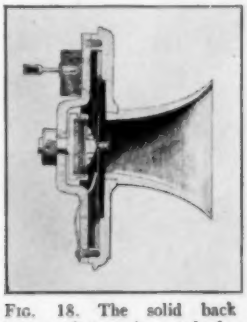


FIG. 18. The solid back transmitter invented by White in 1890 was of a general type of which millions have given good service.

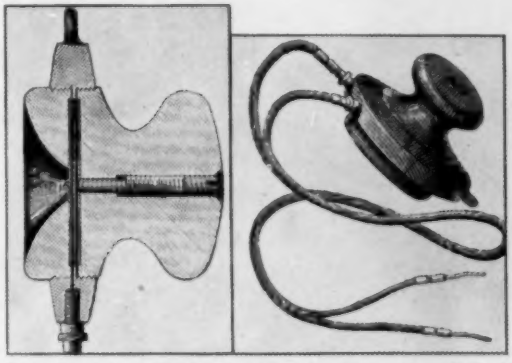


FIG. 19. One of the first condenser transmitters was devised by Prof. Dolbear of Tufts College.

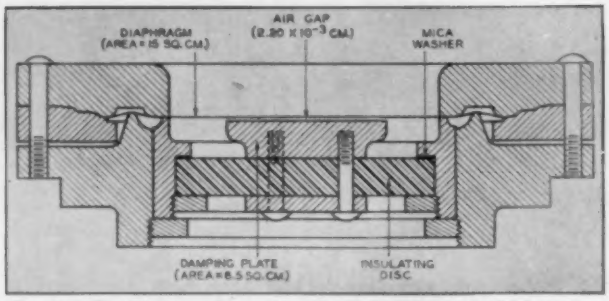


FIG. 21. The Wente condenser microphone of 1917 gave faithful response over a very broad frequency range.

FIG. 20. Carbon granules average 0.011 inch in size. When magnified they look much like chunks of ordinary hard coal. They are hard, clean and free from dust.

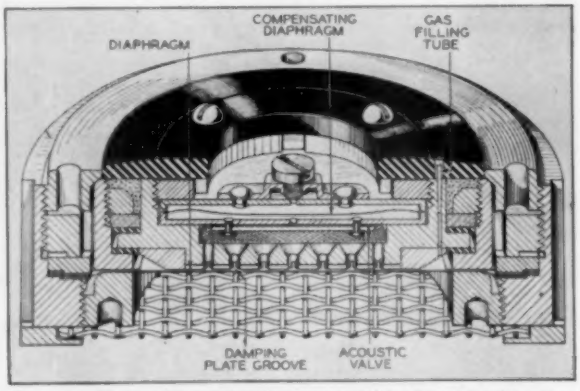


FIG. 22. The condenser microphone was modified by Crandall in 1918 to have a slotted damping plate. This increased the efficiency and also the damping, thus greatly increasing its practical usefulness.

FIG. 23. The centrally damped solid back transmitter became standard in the Bell System in 1917.

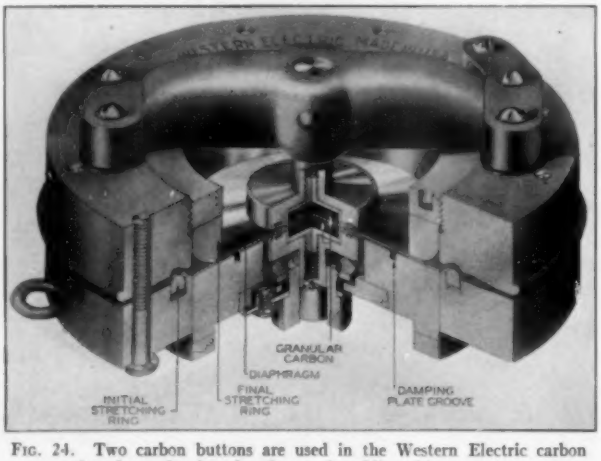


FIG. 24. Two carbon buttons are used in the Western Electric carbon microphone for broadcasting and public address systems.

spring. This instrument as developed for commercial use was more sensitive than the Edison and more rugged, reliable and permanent than the Berliner or Hughes. It rapidly replaced the Edison and Berliner types and was extensively used for many years by the Bell System. Its resistance was about five ohms, and the safe current was about ¼ ampere at 1½ volts.

On September 16, 1878, an English clergyman, Hunnings,[20] received a British patent on a telephone transmitter using a button partially filled with "pulverized engine coke," a light porous form of carbon. American rights to this invention were later purchased by the American Bell Telephone Company and the device was developed into a form suitable for commercial use (Fig. 15–Fig. 16). Like the Blake it was more sensitive than the Edison transmitter and more stable than the Hughes microphone. It could however carry larger currents than the Blake. One of its outstanding difficulties was that the carbon tended to pack into an insensitive condition. It was the type destined to be developed into the most broadly used commercial form.

On July 8, 1879, Gilliland[21] made application for a patent on a combination of a Bell receiver and Blake Transmitter with a common diaphragm. This again shows the early recognition of the need of an amplifier.

The mechanical features of the original Blake type single contact telephone transmitter were retained and the single contacts replaced by a carbon containing chamber much like that of present day deskstand transmitters. These granular carbon designs first went into use in 1885 and were somewhat modified in 1888. Several hundred thousand of them were used in the Bell System during the years following. Like the Hughes and the Blake single contact, these were inertia transmitters.

In 1886, Edison applied for a patent on a transmitter filled

[20] British Patent No. 3647, Sept. 16, 1878; U. S. Patent No. 246,512, Aug. 30, 1881.
[21] U. S. Patent No. 247,631, Sept. 27, 1881; Jl. Inst. Elec. Engs., XLI, p. 535.

with granules of carbonized hard coal.[22] Although great progress has been made in refining and controlling the methods of preparation, selected anthracite coal is still used as the raw material from which most microphone carbon is made.

In 1890 Anthony White invented the so-called solid back transmitter (Fig. 18).[23] In this design a solid bridge or button support much like that of the Edison design replaced the spring support of the Blake granular carbon type and the button was attached to the diaphragm. Other mechanical improvements added to the ruggedness and reliability of this design. It was so satisfactory commercially that the general principle is still used extensively. There are at present about twenty million telephone transmitters of this general type of construction in service.

Continental European telephone practice, particularly in Germany and France, has followed the use of the "insert" or "capsule" transmitter. This usually uses a thin carbon diaphragm and a few granules or pellets of carbon supported in a carbon or insulated metal chamber on the back of the diaphragm and provided with a rear carbon electrode. In some of these the carbon chamber has consisted of a felt annulus glued to the diaphragm. The rear carbon electrode was pressed or cemented on the back of the felt.

Having traced the important early steps in the development of the telephone transmitter it is seen that other types gave place to the variable resistance carbon amplifying type. Particularly in view of the fact that this is still the type most broadly used, it is of interest to note briefly the range of physical principles which broad general interest in the problem has utilized in the search for the best.

Microphones may operate on the principle of temperature change due to the sound waves. These are of two types. In one the motion of the air serves to fan and cool a fine wire

[22] U. S. Patent No. 406,567, July 19, 1889.
[23] U. S. Patent No. 485,311, Nov. 1, 1892.
Rhodes, loc. cit., p. 82.

carrying and heated by a direct current. Such a wire is usually mounted in the mouth of a resonator. Such a structure was used by Forbes[24] in 1887. A microphone of this type was used by Tucker during the war in the detection of large guns.[25] A similar device has substituted a series of fine themocouples for the fine resistance wire. In the second type a fine wire or thermocouple structure is placed close to a sound reflecting surface. In this case there is negligible motion of the air and the structure is alternately heated and cooled by the temperature changes associated with the sound.

The resistance of an electric arc has been caused to vary by the sound. Such a device was experimented with by Dolbear, Blyth, Simon, Hayes and many others.

The resistance of the glow discharge in open air has been caused to vary. A description and demonstration of such a device was given by Thomas before the A. I. E. E. in 1923.[26]

Liquid devices of many types have been devised since the first model by Bell. Elisha Gray devised one of the first liquid transmitters. Edison placed a small drop of liquid between contacts, the contact surface, cross-section and length of the liquid path being varied. Liquid jets have been used in various ways. The jet has been deflected on and off a conducting electrode. The electrode has been vibrated in and out of the jet, etc.

Pressure has been used to modify a flame, the conduction through the flame, the heat transmitted by the flame, etc., being used to control electrical effects.

Sound has been caused to deflect a beam of light on and off a photo-electric cell by means of a diaphragm and vibrating reflector.[27] The diffraction of light across a beam of sound has also been used to cause varying amounts of light to fall on a photo-electric cell.

[24] Proc. Royal Soc. Lond., Vol. 42, p. 141, Feb. 24, 1887; El. Wld., Vol. 9, p. 189, Apr. 16, 1887.

[25] U. S. Engr. School, Occasional Papers No. 63, Washington Govt. 1920.

[26] P. Thomas, Proc. A. I. E. E., Vol. 42, pp. 219–222.

[27] Photophone, Bell & Tainter, Prescott, loc. cit.

A magnet has been made to vibrate outside a vacuum tube and thus vary the flow of electrons. By a mechanical connection through the wall of a vacuum tube a grid has been made to vibrate, thus making the conversion from acoustic to electrical effects.

A bismuth resistance element has been vibrated in and out of a strong magnetic field. As the resistance of bismuth varies with the strength of the field, this provides a possible microphone.

Condenser type microphones were devised by DuMoncel, Dolbear (Fig. 19),[28] Varley and many others since. A recent novel manner of using a condenser microphone has involved the modulation of a high frequency oscillating current instead of the usual direct current in such a manner as to give a rather efficient device.[29]

Piezo electric crystals have been vibrated to generate corresponding electric currents.[30]

Of the magnetic microphones, devices have been made in which the sound mechanically strained a magnetic core of nickel and thus varied its permeability and generated a current. The best known magnetic type microphones are those in which the sound changes an air-gap, in a magnetic circuit, thus changing the number of magnetic interlinkages. The magnetic type in which a coil or conductor has been vibrated in a magnetic field is also well known and dates back within a year of Bell's first publication.[31]

The dimensions of solid conductors, both cross-section and length, have been varied by the sound to cause changes in resistance. The most effective device found has been of this type in which the dimensions of contact points of specially prepared carbon are changed. In fact, it would seem that

[28] A. E. Dolbear, A New System of Telephony, Sci. Amer., June 18, 1881, p. 388.
[29] A. H. Reeves, A Solution of the Problem of the Broadcasting Microphone, Electrical Communication, Vol. VII, p. 258.
[30] A. M. Nicolson, Proc. A. I. E. E., Nov., 1919, pp. 1315–1333.
[31] Siemens and Halske, German Pat. No. 2355, Dec. 14, 1877; British Pat. No. 4685, Feb. 1, 1878.

every known characteristic of matter by which temperature change, pressure change or motion may generate an electromotive force, has been used in the design of microphones.

Until recent years, and then only for special uses where amplifiers are available, other than carbon microphones have been of little more than academic interest. In view of this, it is worth while to consider some of the characteristics of the carbon instrument in greater detail.

Carbon microphones have presented a number of difficulties which for a time limited their usefulness. These have been investigated chiefly in connection with studies of the telephone transmitter. Most of these difficulties have been largely overcome in recent years. One of the earliest recognized is known as "packing." The instrument gradually becomes less and less sensitive. Its sensitivity may be revived by shaking or rapping. Packing is of two types, electrical and mechanical. Electrical packing or cohering occurs if the carbon element is subjected to a voltage such that more than approximately 1½ volts per contact is applied. After an application of such voltage, the transmitter sensitivity is apt to be reduced to the order of 1 per cent of normal sensitivity and very vigorous shaking may be required to revive the instrument. This effect is largely independent of the amount of power dissipated or the time for which the voltage is applied. For example, a carbon button or cell may ordinarily be packed almost as effectively by applying a voltage of 20 to 100 volts to 0.001 mf. and discharging it through the button as by a similar discharge from a very large condenser or by the application of the same voltage from a battery. In fact, if the amounts of power dissipated are large, subsequent heating effects may occur such as to free the carbon and decrease the effect.

Mechanical packing is due to a settling and compressing of the carbon mechanically. In this condition its resistance and sensitivity are low. It is often closely associated with "breathing." Many carbon microphones in certain circuits will, if left

undisturbed, either increase or decrease, depending on design or circuit conditions, or may pass through cycles of resistance and sensitivity requiring anywhere from a few seconds to many minutes per cycle. These effects have been investigated and are known to be associated with mechanical expansions and contractions of the containing chamber plus those of the carbon itself. They are closely related to the type of circuit, the action often being quite different if supplied with constant voltage than if supplied with approximately constant current. The containing chambers may be so designed as to eliminate these effects almost completely, in which case the button will usually not pack. We might illustrate packing by an example: if, on passing a current through a carbon microphone in series with a considerably larger resistance, the resultant heat causes the carbon containing chamber to expand and the electrodes to move farther apart, the resistance will, at first, rise, due to this greater separation of the electrodes. This will increase the heat generated and cause further separation and resistance rise. This may continue, the sensitivity becoming very great, until the separation is such that the granular mass becomes mechanically unstable. The granular mass may then suddenly settle, particularly if jarred or spoken into at this moment. This lowers the resistance and hence the power dissipated in the button so that it then begins to cool, allowing the parts to draw together and compress the carbon into a highly insensitive state. In general, carbon microphones are more stable when supplied with direct current through a resistance as large or larger than the resistance of the button itself.

The resistance of a granular carbon button decreases with increased current. In certain systems this may be advantageous for transmission as, for instance, in a common battery telephone system where high transmitter resistance occurs on the long subscribers' loops where the series resistance is large. This increases the power dissipated in the button over what it would otherwise be, increasing the output. As the loop is

shortened, the lowering in resistance tends to protect the button from excessive power and voltage and excessive heating.

Granular carbon microphones always deliver a certain amount of noise. In modern telephone transmitter designs, however, this noise may be negligibly small. It resembles in character the swishing of leaves. It has been termed "microphonic noise." It might perhaps well be called the inherent or minimum loose contact noise. In amount it is from 15 to 20 db below the output of a carbon broadcast microphone when speaking at normal loudness at a distance of three feet. This noise is undoubtedly due to heating effects at the points of contact between granules. It is not due to mechanical or temperature effects of the containing chamber. No type of carbon appears to be free from this effect and different types differ surprisingly little. It increases about in proportion to the power dissipated in the microphone until the direct current assumes fairly large values; i.e., 0.1 to 0.2 amps. for most telephone transmitter types. When the current is increased further, the noise begins to increase much more rapidly and to depart from its steady, smooth character and become erratic. Sounds like miniature explosions or sometimes continuous oscillations may occur. From its likeness to the sound of frying fat, it is sometimes called "frying." Most commonly, however, this noise has been called "burning." Viewed under a glass minute points of incandescence may be seen at the contacts. This noise limits the use of the carbon microphone in modern practice, where amplifiers are involved, to work where the sounds to be transmitted are sufficiently loud to mask this noise as in usual telephone use.

Carbon may show considerable aging from the condition when it is first prepared by roasting. It may age either as a result of mechanical agitation or burning. As it ages, its resistance increases, the increase often amounting to several hundred per cent.

Considerable work has been done in the investigation of the

pressure-resistance characteristic of carbon cells. This approximates an hyperbola over quite a broad range of pressure and resistance although the exact characteristic departs from this curve and depends on a number of factors beyond the scope of this discussion.[32] Based on this characteristic, the character of the current resulting from a sinusoidal variation of pressure has been studied.[33] The effects are complicated. For many purposes, the distortion due to a failure of the current to vary in exactly the same manner as the resistance is not important, provided the resistance in the circuit external to the microphone approximates or exceeds that of the microphone itself. Such effects are often minimized by the use of two carefully matched buttons operated push-pull.

The mechanism of electrical conduction through a mass of granular carbon has been subjected to much study and many theories have been advanced to explain the phenomena observed. It has now been quite well established, however, that the current crosses the contacts through minute sub-microscopic irregularities in the surface in actual contact. As the pressure is increased, these protuberances are deformed so that the areas in contact and the number of contacts are increased and hence the electrical resistance is decreased. The gas which adheres to the surface of the carbon tends to restrict these points of contact and behaves like an elastic layer between grains.

Of the many substances which have been tried for use in a loose contact microphone, granular carbon appears to be much the best (Fig. 20). The combination of the strength, elasticity, the character of the surface as regards its roughness, the manner in which gas adheres to the surface, the heat conductivity, electrical conductivity, its infusibility, the fact that the oxides are gases, the value of the specific heat and the fact that, if properly prepared, the gases adhering to the surface are not

[32] Goucher, Science, Nov. 7, 1930, pp. 467–470.
[33] L. S. Grandy, A. I. E. E., Jour. (46), pp. 426–430, 1927.

given up except at high temperatures, make carbon much the most satisfactory microphonic material known. Microphone carbon is extremely hard, being nearly as hard as diamond. It remains hard at high temperatures. Its ratio of thermal to electrical conductivity is very high compared with other materials. This results practically in much less heating at the minute points of contact. Due to the combination of the characteristics mentioned, there is what might be loosely termed a critical voltage for most contacts. This is the voltage beyond which we cannot go without welding or cohering the contacts. For metals this is low. The fact that it is low was used in the iron-filing detector of early radio days. Such a detector was simply a cell of loose contact material which was very easily packed electrically or cohered. This "critical voltage" of most metals is of the order of 0.1 volt. For carbon it is about 1½ volts. While other materials have been found with higher values of "critical voltage," they are of such high resistance or have other characteristics which are so objectionable, that they are not at all adaptable for use in a microphone. In the light of present day knowledge, it appears probable that carbon will continue to be used as the loose contact material for microphone buttons wherever the conditions of use are such as to demand a microphone which is an amplifier. Due to the large amplification (about 30 db) obtainable with a carbon button, it seems unlikely that amplifying transmitters will be replaced in the near future for at least the great bulk of telephone work.

In most of the earlier carbon transmitters, the granular carbon was placed between two parallel disc electrodes separated from 0.05″ to 0.15″. One of these discs was vibrated by the diaphragm or composed the diaphragm itself so that the maximum agitation and hence aging occurred at this part of the electrical path, the agitation decreasing with increasing distance from the front electrode. Recently, this "direct action" type of carbon cell has in several designs been replaced by a button in which two ring electrodes are separated by an insulat-

ing barrier, the agitation being conducted to the granular mass by an electrically insulated element. In this type, known as the "barrier" button, the maximum agitation occurs at somewhere near the middle of the path through the granules. The aging effects are not localized at the electrodes. This type has shown low burning and long life. The earlier type buttons were usually filled only about two-thirds full. In certain recent types in which improvements in design have greatly reduced the slow expansions and contractions of the cell caused by heat, there is little or no breathing and the chamber is almost completely filled with granular carbon.

The carbon granules are of such size that there are about 50,000 granules per cubic centimeter. Buttons usually contain anywhere from 3,000 to 50,000 granules, depending on the particular design.

The telephone handset which has come into broad use by the Bell System during the last few years placed extremely severe requirements upon its transmitter. It must operate in any position and all of its performance characteristics must remain reasonably constant throughout all the various positions and with all the motion to which it is subjected. Moreover, it must maintain its good characteristics over a long life in spite of being subjected to very severe mechanical shock each time it is used. Only recently has it become possible to meet these requirements.

The Bell System handset transmitter uses a diaphragm which is very light, stiff and well damped. The electrical output is maintained partly by the use of a resilient method of supporting the diaphragm which is not clamped. The carbon chamber is practically non-breathing, is in front of the diaphragm and is filled practically full. It is of the barrier type.

The carbon microphone has presented great difficulties in experimental study and analysis as a vibrating structure. This is due to the variable character of the carbon cell, both mechanically and electrically. For this reason most progress has

been made in both the theoretical and experimental studies of such structures by the use of receivers or electromagnetic microphones. Contributions to the theoretical and also the experimental technique have been made by Poincaré,[34] Kennelley,[35] Wegel,[36] Wente,[37] Crandall,[38] Gerlach,[39] Mallett and Dutton,[40] Kellogg,[41] Maxfield,[42] Harrison,[42] Moore,[43] Jones,[44] and many others.

About 1915, the vacuum tube amplifier became a potent influence on the development of microphones for certain applications, particularly where cost was not important. It did two things: it made it feasible to use, in these applications, a microphone of low sensitivity or efficiency and it created fields of usefulness for instruments of this type. It shifted the emphasis, at least in places where low cost was not a controlling element, from a magnitude of output basis to quality or faithfulness of reproduction, uniformity and reliability. In addition, it offered possibilities of exact measurements of acoustic effects if used with a suitable microphone. This influence was almost immediately reflected in the development of a very high quality condenser microphone by Wente (Fig. 21). This instrument was developed for use in such acoustic researches and its commercial applications were developed later. The faithfulness with which it reproduced sounds over a very broad range both of frequency and intensity represented a vast improvement over the previous microphones. It was later improved by Crandall (Fig. 22),[45] has received much commercial

[34] Écl. Électr. 50, pp. 221–234, Feb. 16; 257–262, Feb. 23; 329–338, Mar. 9; 365–372, Mar. 16, and pp. 401–404, Mar. 23, 1907.
[35] Electrical Vibration Instruments (MacMillan).
[36] A. I. E. E., Jour., Oct., 1921, pp. 791–802.
[37] Phys. Rev., May, 1922, pp. 498–503.
[38] Theory of Vibratory Systems and Sound (Van Nostrand).
[39] Phys. Zeit., Vol. 25 (1924), p. 672 and 675.
[40] I. E. E., Jour., May, 1925, pp. 502–516; I. E. E., Jour., Oct., 1923, pp. 1134–1138; Proc. Phys. Soc., Feb., 1921, pp. 139–141.
[41] A. I. E. E., Jour., Sept., 1925, pp. 1015–1020.
[42] Bell System Tech. Jour., 1926, pp. 146–147.
[43] Bell System Tech. Jour., 1927, pp. 230–247.
[44] Soc. Motion Picture Eng., Jan., 1931; Bell System Tech. Jour., pp. 46–62.
[45] Phys. Rev., June, 1918, pp. 449–460.

application and is used as the transmitter of the International Reference Standard with which the volume efficiencies of all commercial telephone transmitters are compared.[46]

Acoustic researches require as the most important tool for the use of the investigator a microphone whose calibration can be definitely determined and which will remain fixed. Carbon microphones do not meet this requirement satisfactorily. Such an instrument should operate over a broad range of frequencies and intensities. These requirements are very admirably met by the condenser microphone and its development has greatly stimulated and facilitated precise acoustic measurements. Such measurements would be further facilitated in the higher frequency ranges were the dimensions of the microphone such that its interposition in a sound field caused no distortion thereof. The character and extent of this field distortion has, however, been studied and methods and data developed by which such effects can either be controlled[47] or proper corrections be introduced.[48] The high mechanical impedance of its diaphragm adapts it well for investigations of sound in tubes or closed spaces.

If we wish to summarize the facts recounted above we see that during the period immediately following 1875 almost every conceivable type of microphone was tried. With the available technique, however, it was not possible to submit the different types to detailed quantitative study or analysis. They were used chiefly as telephone transmitters. The magnitude of the electrical output tended to exceed extreme faithfulness of reproduction in its practical importance. The granular carbon type rapidly outdistanced all competitors. Intensive work on this type of transmitter led to successive improvement in both these factors and also in the reliability of the instrument, the uniformity of commercial product and the uniformity of performance during its life (Fig. 23).

[46] Martin and Gray, Bell System Tech. Jour., 1929, pp. 536–559.
[47] Ballantine, Phys. Rev., Dec., 1928, pp. 988–992.
[48] Aldrich, P. O. E. E., Jour., Oct., 1928, pp. 223–225.

Since the publication in 1917 of Wente's work on the condenser microphone, there has been an increased demand for microphones which will reproduce sounds of widely varying character with extreme fidelity. Various lines have been followed in the development of different types. The condenser microphone has, as stated, been used quite broadly. The magnetic type with moving strip conductor actuated directly by the sound has been used abroad [49] and is coming into use in this country.[50] The stretched diaphragm air-damped carbon microphone (Fig. 24) has seen considerable use in this country, and

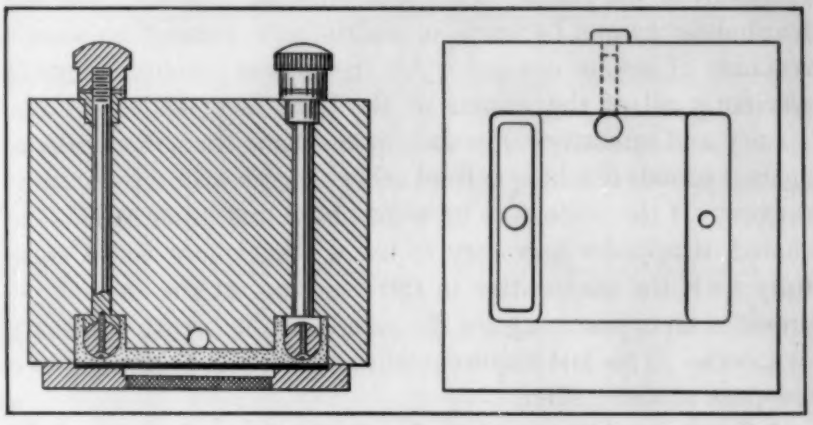


FIG. 25. The Reisz marble block carbon microphone has been used for European broadcasts during the last few years.

in Europe the Reisz,[51] transverse button microphone placed in a heavy marble block has seen considerable use (Fig. 25). The electrical output of such instruments is usually much lower than that of commercial telephone transmitters, the sacrifice being quite justifiable since, in their application, these microphones are usually associated with a suitable vacuum tube amplifier. Where the source of sound is somewhat remote from the microphone, so that the actual sound power available is very low, and

[49] Gerlach and Schottky, Phys. Zeit., Vol. 25 (1924), p. 672 and p. 675.
[50] Electronics, Feb., 1931, p. 492.
[51] U. S. Pat. 1,634,210, June 28, 1927.

where quietness of operation is essential, loose contact noise bars the use of the carbon microphone, and the magnetic, or condenser instrument is to be preferred.

Microphones have been in demand in recent years for a wide and growing variety of uses. "Anti-noise" transmitters are demanded in airplanes and other noisy places. Although various principles have been suggested and used, it appears that most of the obtainable improvement in this direction can be realized merely by the use of a highly damped instrument. Beyond this, further improvement seems to rest chiefly on the exclusion of the noise. That this must be true and that the transmitter cannot be made to discriminate among the sounds reaching it seems obvious. An instrument cannot transmit efficiently all of the sounds of the voice over its broad frequency and intensity range and, at the same time, discriminate against sounds reaching it from other sources within these same ranges. If the voice is to be transmitted and other sounds excluded, it appears necessary to use a mouthpiece which carefully seals the transmitter to the face and, at the same time, provides an opportunity for the escape of the breath necessary in speech. This last requirement has been met by the use of a low-pass acoustic filter.

A frequency response curve has been taken using one of the earlier Blake single contact transmitters, of the type designed in 1878. This is shown in comparison with a similar curve for a Western Electric condenser microphone. Both curves are for constant sound pressure (Fig. 26 and Fig. 27). The contrast between these two curves needs no comment. It shows the great advance which has been made in fidelity of reproduction and it also shows at what sacrifice in magnitude of output.

If it were possible to state the requirements of future microphones in a single specification, it might be possible to make some predictions as to the type and range of future improvement. This, however, is not possible because designs will be needed for a wide variety of conditions of use. Some will be

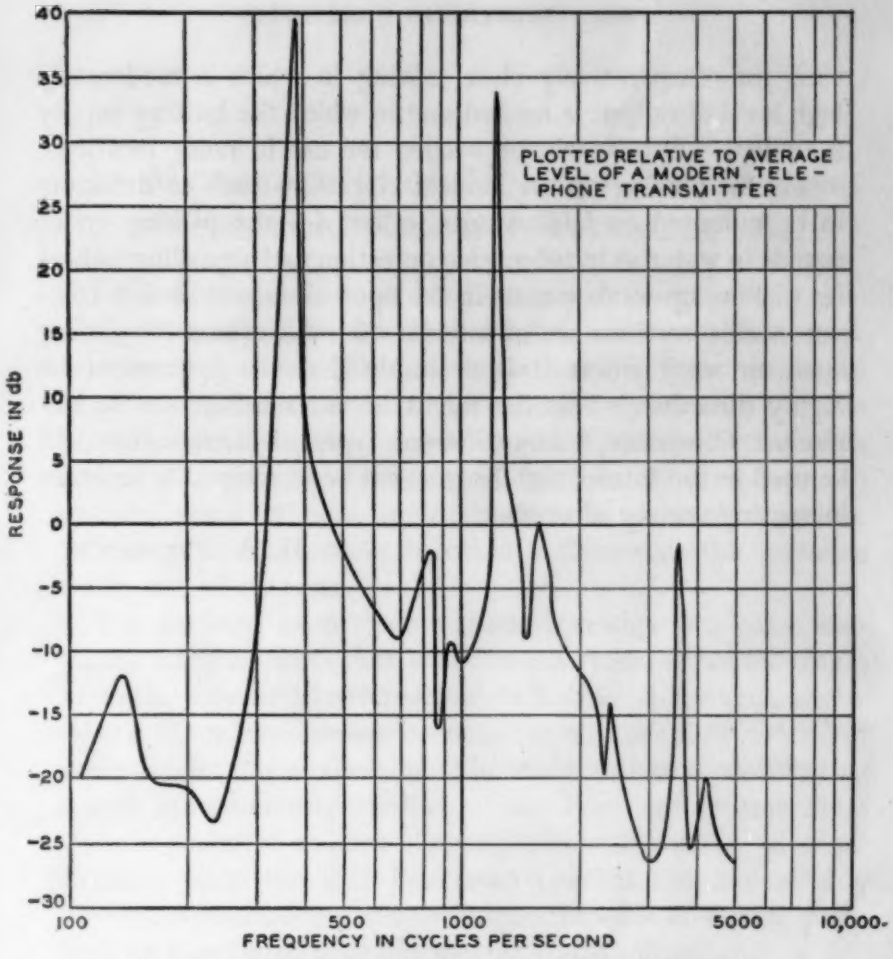


FIG. 26. Response frequency characteristic—Blake single contact transmitter of 1878.

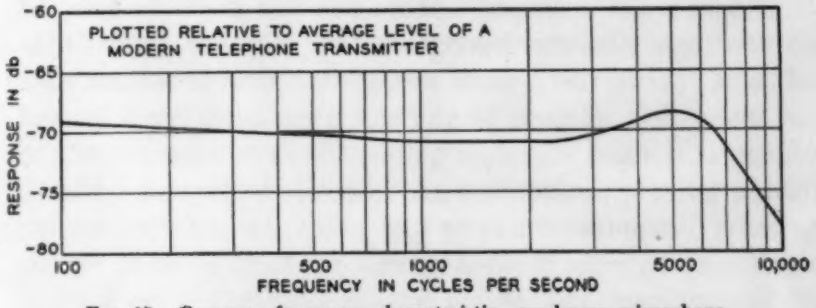


FIG. 27. Response frequency characteristic—condenser microphone.

used for comparatively close talking in which a moderately high level of output is needed and in which the battery supply is limited. Others will be needed for use in noisy locations, others for picking up mechanical vibrations such as detectors to be mounted on bank vaults, others for the picking up of sounds in water as in submarine detection and signalling, others for picking up weak sounds in the open air where sounds coming in all directions are of interest and still others for similar open air work where it is desirable that the instrument be highly directive. This list might be extended almost indefinitely. Obviously, many different types of microphones will be used in the future, and designs will be developed to meet an increasing variety of needs.

H. A. FREDERICK

The Measurement of Noise; a New Service of Electrical Research Products, Inc.

THE widespread use of machinery and the growth of congested municipalities have created noise problems which have become acute. Although noise has long been recognized as undesirable, it has only been comparatively recently that the full gravity of its harm was realized. Leading psychologists and physiologists have undertaken costly experiments to measure the effect of noise upon the human physical organism. Efficiency experts have endeavored to determine the economic waste caused by noise.

The findings from these various investigations have suggested many benefits that would result from successful efforts to abate noise and have resulted in a demand for such abatement. To achieve proper economic and satisfactory control of noise, a scientific analysis must be made and each contributing source independently studied. Only then can recommendations be prepared which will assure adequate isolation or elimination. Since the Bell Telephone Laboratories had already developed instruments and techniques capable of solving problems such as these, their aid was naturally enlisted.

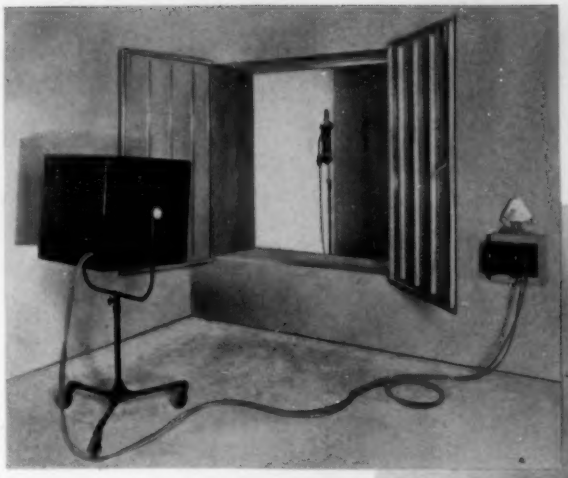
The need for similar engineering advice in the field of architectural acoustics has also become urgent. The necessity for satisfactory acoustics was recognized centuries ago with the construction of cathedrals, opera houses, and concert halls, but lack of a sufficient understanding of acoustic phenomena and of the characteristics of building materials made it impossible to effect desired conditions. An auditorium, proving acoustically acceptable, was hailed as a great achievement. What appeared to be an exact reproduction would often prove most unsatisfactory. Fortunately, the public was cognizant of the

difficulties encountered and was tolerant. Until recent times, this toleration persisted, but with the ever increasing number of available auditoriums, the public has become selective.

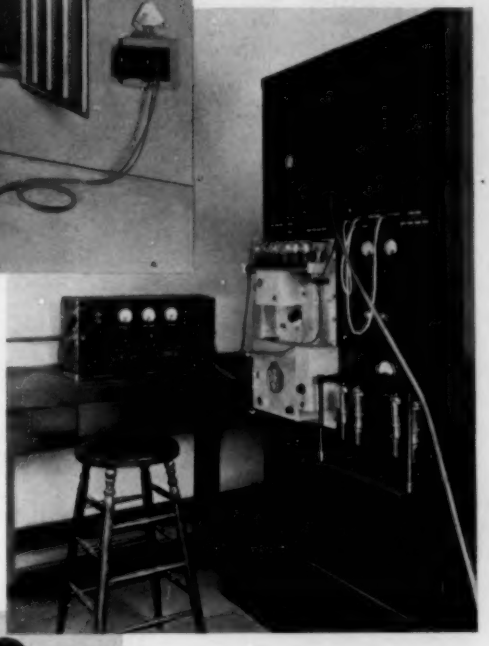
With the introduction of sound amplifying and reproducing devices in theatres, satisfactory acoustic conditions became an important economic necessity. No matter how ingenious their conception, or how perfect their manufacture, these devices could hardly justify their inclusion where abominable "listening conditions" existed. A demand for engineering advice on acoustic conditions was thus created. The Bell Telephone Laboratories had long investigated acoustic phenomena, and through their own and other kindred researches, an exact science had been established. Here again, it was only natural that their aid should be sought.

Some two years ago Electrical Research Products, Inc. established a department for disseminating acoustic information to their licensees in the talking motion picture field. Functioning as a noncommercial unit, this department acoustically analyzed over five thousand theatres and prepared recommendations for their correction. During these studies, considerable practical experience was gained, as nearly every type of architectural acoustic problem was encountered. Publicity, attendant upon each successful achievement, created a more general demand for this acoustic consultation and architects began seeking advice on other types of auditoriums. With the realization that a thorough study of auditorium acoustics necessitated knowledge of all catacoustic and diacoustic phenomena, a new demand became apparent, and aid was sought on all types of structures.

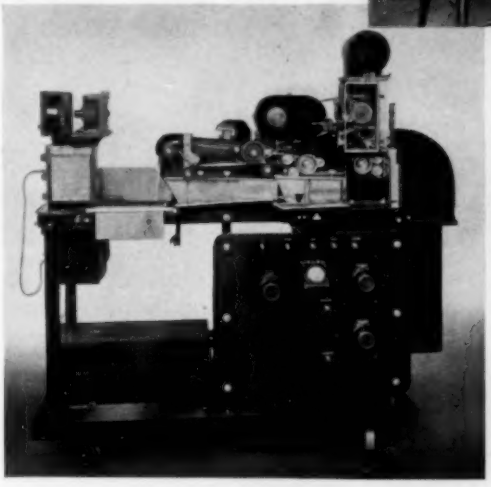
To meet the growing general demand for noise abatement and acoustic control, the services of the department were commercialized, thereby effecting a new application of telephone research. Instruments, experimental facilities, techniques, and practical experience were available. It was essential that this organization function purely as engineering consultants, with-



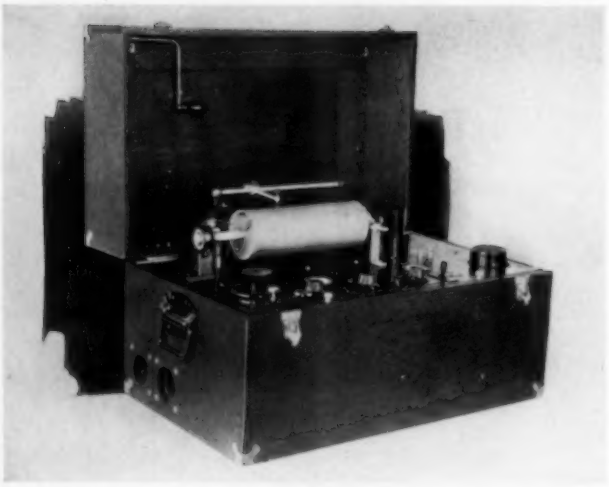
(Left) View in Sound Transmission Laboratory; samples of materials are tested here.



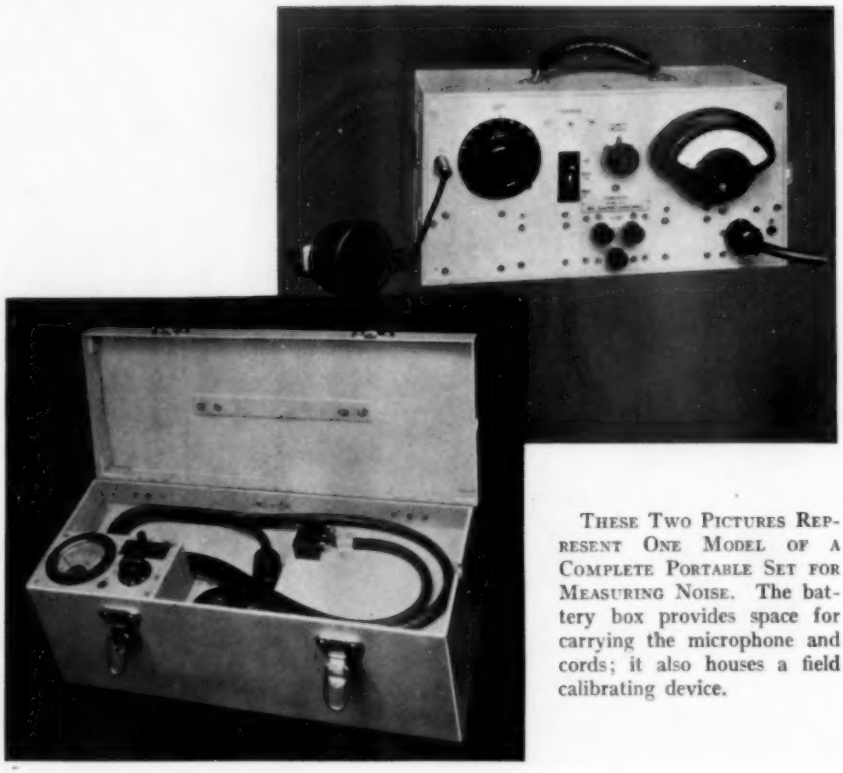
(Right) Part of Apparatus Used in Testing Materials; the ear is replaced by electrical instruments.



(Left) The Rapid Record Oscillograph—an extremely valuable instrument in acoustic research.



(Left) A Spark-Chronograph Type of Reverberation Meter Employed in Auditorium Measurements.



These Two Pictures Represent One Model of a Complete Portable Set for Measuring Noise. The battery box provides space for carrying the microphone and cords; it also houses a field calibrating device.

out interest in the manufacture, distribution or sale of any acoustic or noise isolating materials or devices. Only in this way could economical, practical and unbiased acoustic advice be disseminated.

Since the inauguration of this new Acoustic Consulting Service in January of this year, the scope of its activity has been extraordinarily wide, and valuable experience has been gained with the solution of each new problem. Acoustic analyses have been made, and specifications for correction prepared on all classes of architectural construction, from auditoriums seating over twenty thousand people to the private office of an executive, from recording and broadcasting studios to band shells, and from cafeterias to libraries. In fact, a practical solution of acoustic problems occurring throughout the architectural range has been effected. The instruments and theories developed in the Bell Telephone Laboratories have proven most adequate.

Noise analysis and the preparation of specifications for its control has offered a widely diversified field; and nearly every problem has necessitated a different application of engineering principles. Noises created in tunnels and subways, and by elevated railways, automobiles and airplanes, have been studied; and means of reducing or eliminating them have been recommended. Of equal importance, though not quite so formidable, have been investigations of noise emanating from office machinery, ventilating fans, and other extraneous sources. Instruments are used in this work, as it is only after a measurement of each contributing component that an individual noise may be thoroughly analyzed. By redesigning machine parts or introducing isolating materials or devices, a desired amount of reduction may be assured. Since effective solutions have been achieved for the above types of problems, new demand has become apparent. Inquiries have been received for the design of special acoustic instruments for mechanical inspection of noisy machine parts. Information also has been requested

on the construction of acoustic signal devices which may be distinguished from surrounding noise. As each new noise problem is created, a new field for this service is established.

Although noise abatement and acoustic control predominate in the field, there is yet another branch of allied activity that is worthy of mention. The testing of materials, structures, or devices to determine their acoustic characteristics has become an important part of this new work. Laboratories have been established in New York and Los Angeles, equipped to measure accurately the absorbing, transmitting, and reflecting qualities of materials, and for conducting comparative noise tests. This latter function permits the design of quieting devices and the conduct of experiments on the effectiveness of acoustic signalling systems.

Certain specific commercial aspects of this new consulting service have been discussed above, but it must be borne in mind that other types of acoustic or noise problems may be solved with equal facility. Fundamentally all problems in sound and vibration are the same, so when particularly complex obstacles are encountered, their analysis may be achieved by recognizing basic similarities. From this point, special apparatus or new instruments may be developed which will adequately solve the problem. Through the establishment of this Acoustic Consulting Service, a highly specialized engineering field has been developed, and new commercial applications have been found for experimental discoveries made during telephone research. And, thus, another service has been rendered the public.

S. K. Wolf

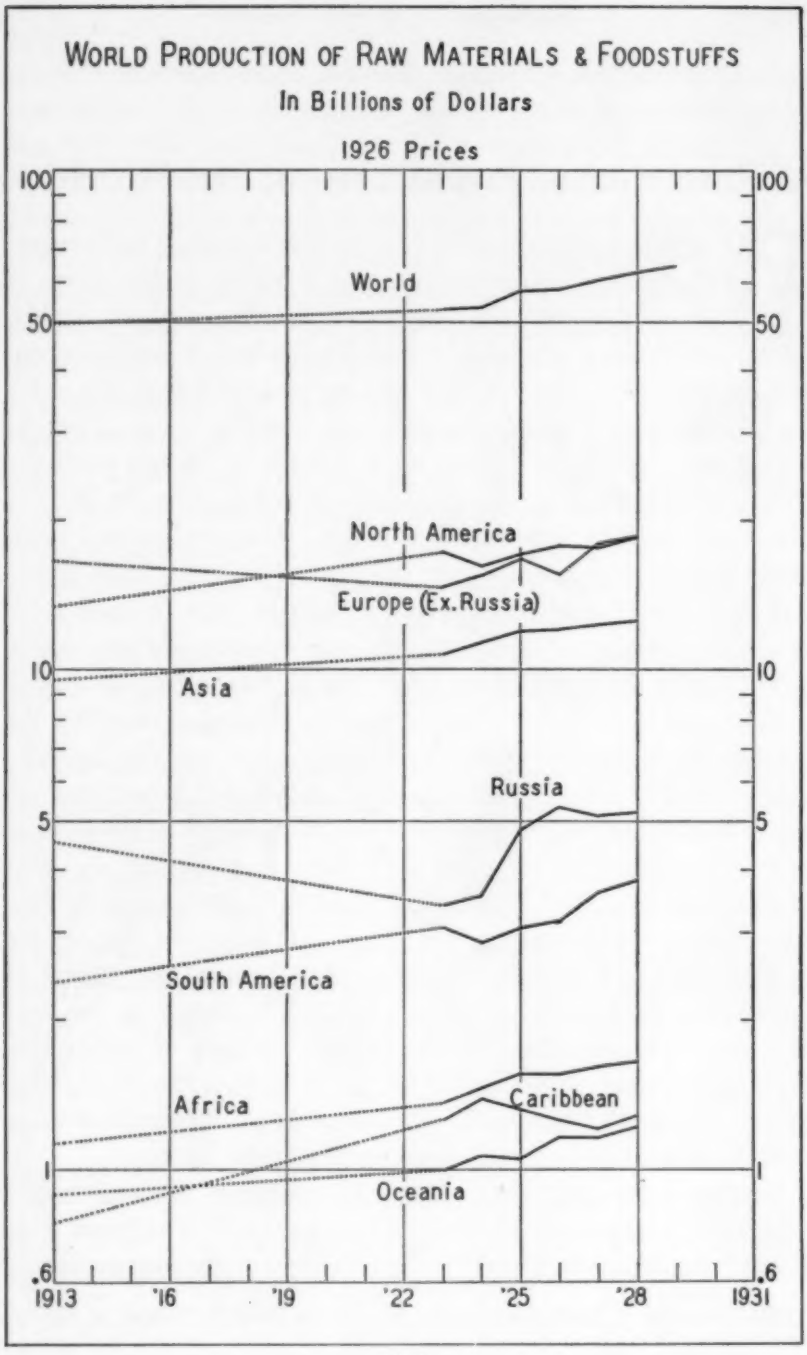
The Primary Production of the World

THE severe decline in prices on the stock market in October, 1929, marked the termination of a period of five years of practically uninterrupted prosperity in the United States. Never before in a period of equal length had American crops been so bountiful; never before had we extracted from the earth such large quantities of minerals and metallic ores. Concurrently, our forests were yielding a volume of timber products sufficient to support a tremendous building boom. In fact, so abundant was the production of basic raw materials and foodstuffs which accompanied our national prosperity that it has sometimes been claimed that this country was primarily responsible for the maladjustments and disequilibrium which have latterly disrupted the crude material markets of the world.

What are the facts? Is it true that during prosperity the United States increased its production more rapidly than did other nations? To answer this moot question it is necessary to know what the world in general has accomplished in the field of primary production. Fortunately there is available an index of the world's production of crude foodstuffs and raw materials, compiled by the Economic and Financial Section of the League of Nations.[1] (It is to be regretted that data on the output of manufacturing industries are not available, except in the case of a very few countries. Concern over the lack of such information, however, is tempered by the fact that the production of raw materials—primarily for purposes of fabrication—is a process only once removed from manufacture itself.)

The accompanying chart shows the League of Nations' index, both for the world and for continental groups. The chart is on a logarithmic vertical scale, equal vertical distances measured

[1] Memorandum on Production and Trade, 1923 to 1928/29. League of Nations, Geneva, June, 1930.


WORLD PRODUCTION OF RAW MATERIALS & FOODSTUFFS
In Billions of Dollars
1926 Prices
100
50
10
5
1
.6
World
North America
Europe (Ex. Russia)
Asia
Russia
South America
Africa
Caribbean
Oceania
1913
'16
'19
'22
'25
'28
1931

upward representing equal percentage increases, and equal vertical distances measured downward representing equal percentage declines. The North American group includes the United States, Canada, Labrador, Newfoundland and Alaska. The Caribbean group includes the West Indies, and the continental states from Mexico to Panama. Since the Union of Soviet Socialist Republics has abandoned the old distinction between European and Asiatic Russia, it is more convenient to show the U. S. S. R. as one continental group. Accordingly, the separate indexes for Asia and for Europe are exclusive of Russia. The world index and the separate component indexes are available for the year 1913 and for the years from 1923 to 1928 or 1929. In the chart the years from 1913 to 1923 are bridged by a straight dotted line.

It may be wondered why, if this chart measures physical production, the scale is "in billions of dollars." Obviously, to add together commodities so varied as wheat, pig iron, rubber, etc., it is necessary first to express them in terms of a common denominator. The common denominator used is value. A representative world price is chosen for each commodity and the physical quantity of the commodity produced in each year is multiplied by this price. The prices selected are averages for the year 1926, and are used as constant weights throughout the period of the index. The index itself is based upon data representing the production of 62 crude foodstuffs and raw materials, except that the production of foodstuffs in China is excluded since no data are available. The fact that the latest point on the world index is an estimate for 1929, while the latest points on the individual components are for 1928, is of no consequence for purposes of this discussion.

The chart indicates clearly, by comparison of 1923 with 1913, the losses in European and Russian production which occurred as a result of the war and the Russian Revolution. While 19 per cent below European output in 1913, North American production in 1923 exceeded that of Europe by an

equal relative amount. Russian production declined twice as sharply as European production. Aside from European production, all of the other indexes on the chart rose in the decade 1913 to 1923. The extremely sharp rise in Caribbean output for the most part reflects the rapid development of the petroleum industry in Mexico. The accompanying table shows the changes from 1913 to 1923, both in dollar value aggregates and in percentages.

WORLD PRIMARY PRODUCTION—1913 TO 1923

Aggregates in Millions at 1926 Prices

	1913	1923	Net Change	
			Amount	%
Europe (excl. U. S. S. R.)	$16,647	$14,532	−$2,115	−13
U. S. S. R.	4,576	3,399	− 1,177	−26
North America	13,471	17,326	+ 3,855	+29
Caribbean	785	1,273	+ 488	+62
South America	2,385	3,070	+ 685	+29
Africa	1,115	1,372	+ 257	+23
Asia	9,692	10,698	+ 1,006	+10
Oceania	901	1,001	+ 100	+11
World	$49,572	$52,671	+$3,099	+6.3

First of all, therefore, the chart shows that by 1923 North America had become the leading producing area in the world. This leadership was, of course, associated with the considerable expansion which had taken place in American export trade accompanying the transition of the United States from the status of a debtor nation to that of a creditor nation.

But what has taken place during the period from 1923 to 1929 which was characterized by substantial economic recovery in Russia and in Europe and by widely diffused prosperity throughout most of the rest of the world? On this question the chart brings out the highly interesting and pertinent fact that North American output from 1923 to 1928 increased at a distinctly less rapid rate than output in any other continental group except the Caribbean. Just as the Caribbean area made

the most rapid percentage gain between 1913 and 1923, due to the development of the petroleum industry in Mexico, so its negligible net increase from 1923 to 1928 largely reflected the declining relative importance of that industry. The table gives the story in numerical terms.

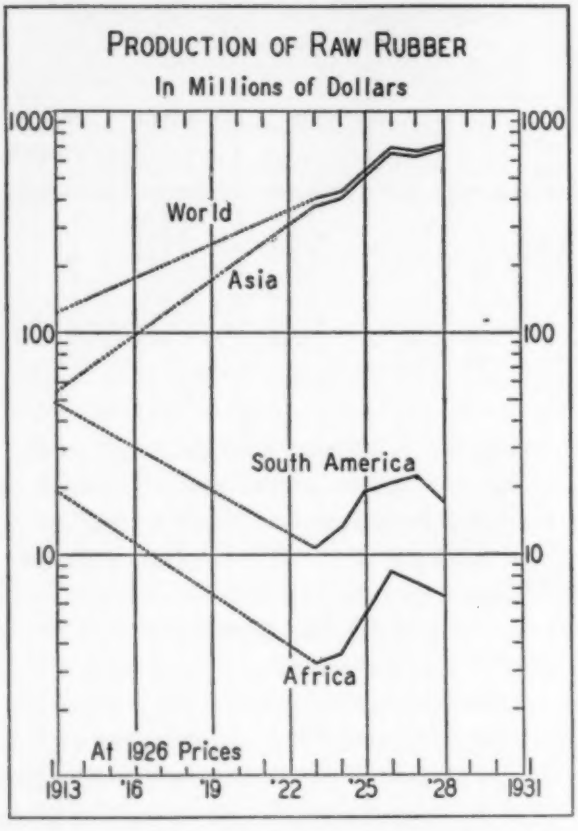
WORLD PRIMARY PRODUCTION—1923 TO 1928
Aggregates in Millions at 1926 Prices

	1923	1928	Net Change	
			Amount	%
Europe (excl. U. S. S. R.)	$14,532	$18,544	+ $4,012	+28
U. S. S. R.	3,399	5,195	+ 1,796	+53
North America	17,326	18,482	+ 1,156	+6.7
Caribbean	1,273	1,288	+ 15	+1.2
South America	3,070	3,814	+ 744	+24
Africa	1,372	1,670	+ 298	+22
Asia	10,698	12,565	+ 1,867	+17
Oceania	1,001	1,219	+ 218	+22
World	$52,671	$62,777	+$10,106	+19

From these figures it appears that the truth of the matter is that dominating the whole period was the rapid increase in European output, which absorbed no less than 40 per cent of the total world increase of 10 billion dollars between 1923 and 1928. North American output, which in 1923 was 19 per cent higher than that of Europe, had been outstripped by Europe in 1927, and in 1928 was a fraction of 1 per cent lower than European output. Russia, accounting for only 6 per cent of total world primary production in 1923, as compared with 33 per cent for North America, actually increased her production between 1923 and 1928 by a greater physical volume than the United States. In 1928, Russia accounted for 8 per cent of the world's output as compared to 29 per cent for North America.

If these figures are trustworthy, therefore, North America has been far from being the sole, or even the prime, contributor to the creation of those plentiful supplies of raw materials which have recently been a powerful factor in depressing the world's markets.

The data underlying these indexes reveal tendencies too numerous to mention in the direction of a geographical redistribution of the total production of basic commodities. For instance, the increase in per capita meat consumption in Europe, as opposed to a decline in this country, is reflected by a rapid



rise in European production and a slowing down in American output of the products involved. Another example is provided by the geographical changes in the production of crude rubber. As shown by the data on the accompanying chart, Asia produced only 45 per cent of the world's rubber in 1913. Of the remaining output, 39 per cent was produced in South America and 16 per cent in Africa. Fifteen years later, however, in

1928, 95 per cent of the rubber came from Asia, 4 per cent from South America, and only 1 per cent from Africa. Incidentally, the case of rubber brings out a weakness in any index of this sort. It was pointed out that the production series were combined on the basis of 1926 values. Between 1926 and 1928, the price of rubber declined about 54 per cent, while the prices of wholesale commodities in general declined only 2 per cent. Obviously, by continuing rubber in the index with 1926 prices there is a marked tendency to overstate its importance.

So far, this discussion of the League of Nations' index of the production of crude foodstuffs and raw materials has concerned itself with the matter of territorial distribution of output. Something might well be said, however, regarding the individual commodities included in the index, although the number of them—62 in all—makes impossible a detailed description of the changes which have taken place in their production. Taking production in 1913 as 100 for each of the 62 commodities, the 1928 points ranged from 71.0 in the case of rape-seed to 1,036 in the case of artificial silk. One method of examining these 1928 points for the individual commodities is to array them in order of magnitude and to find the points at which the list of commodities may be divided into four equal parts. Such points are called quartiles. The results of such a procedure are as follows:

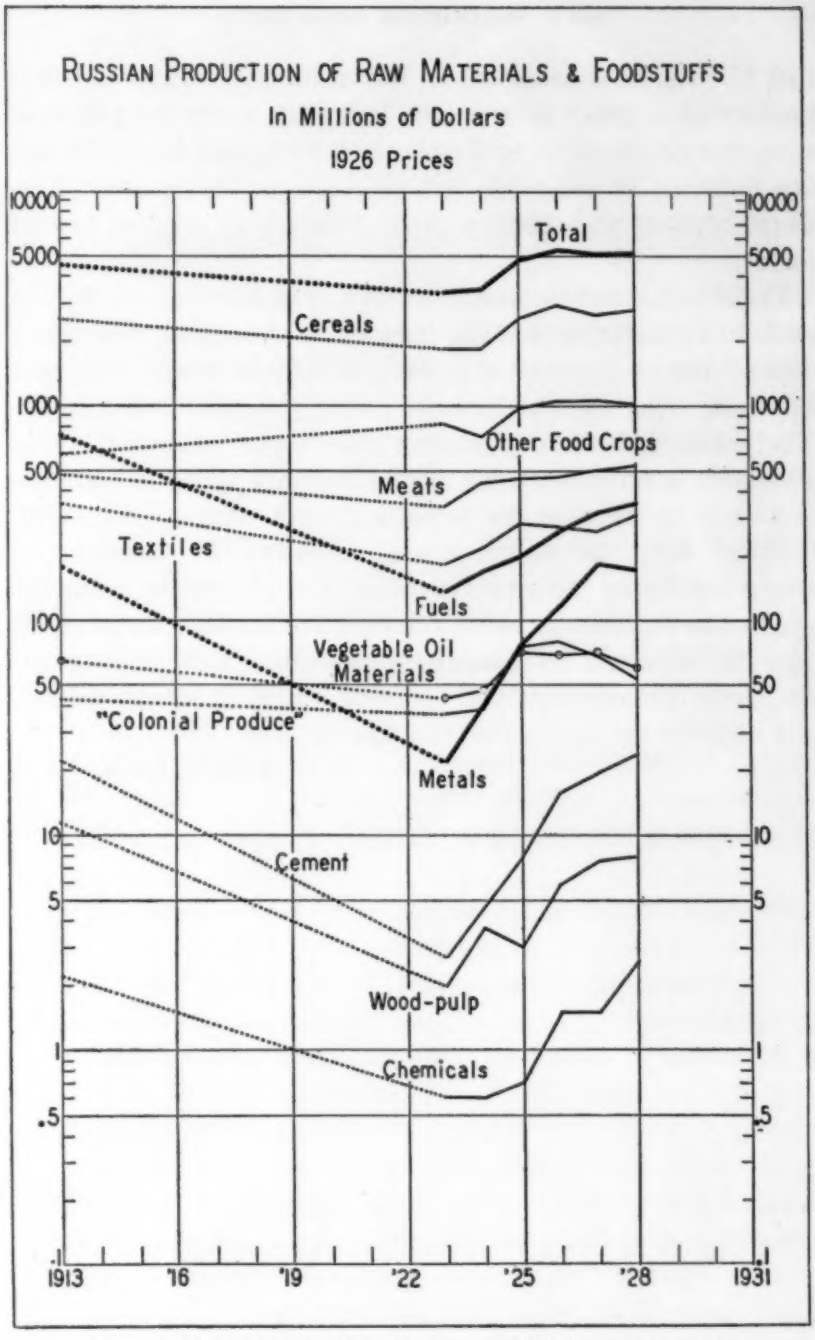
Highest point	1,036.0
Upper Quartile	190.5
Median	137.0
Lower Quartile	114.0
Lowest point	71.0

That is, during the period from 1913 to 1928 the output of half of the commodities increased between 14 per cent and 90.5 per cent, the other half showing changes outside these limits. The median shows the increase above and below which fall exactly half of the items; its value in this case is 137 per cent of the 1913 output. Interestingly enough, the composite world index itself in 1928, stands at 126.6 per cent of the 1913 level.

The reason for this difference between the median increase and the composite index lies in the fact that increases have been smaller in the case of foodstuffs than in the case of raw materials and the former class of products are more important in the index than the latter.

The increase in world population between 1913 and 1928, as estimated by the League of Nations, was 10 per cent, or less than half the increase in the world index of primary production. However, if we split the production index into two groups, crude foodstuffs and raw materials, we find an increase between 1913 and 1928 in foodstuffs output of only 17.5 per cent, as compared with one of 40.0 per cent in raw materials. That is, the production of crude foodstuffs was not greatly out of line with population growth, but the percentage increase in the production of raw materials was four times as great as that in population. This disparity is a natural development. The world in the past decade has been improving its standard of living. The demands made on production have not been so much for foodstuffs as for fabricated articles.

In view of the exceptionally high percentage gain in Russian output since 1923 and because of the general interest in the accomplishments of the Soviet Republics, the indexes compiled by the League of Nations on the production of important commodities entering into the overall index for U. S. S. R. shown in the first chart are presented graphically in the chart which follows. This chart shows the high degree to which primary production in Russia has thus far been confined to foodstuffs. It will be noted, indeed, that the composite index is a close replica of the index of cereal production; in 1928 cereal production constituted 52 per cent of all output reflected in the composite index. At the same time the largest percentage increases have been in those products which are characteristic of a growing industrial nation, such as fuels, metals, cement, etc. Such apprehension of the consequences of the increases in Russian production as exists, however, does not arise from the fact



Note: "Colonial Produce" in the League of Nations' index includes coffee, cocoa, tea, hops and tobacco.

that U. S. S. R. is becoming an increasing contributor to world production so much as from the fact that, under the political-economic organization of Russian industry, costs of production are fictitious or unknown and products are being offered on world markets at arbitrary prices bearing no relation to cost factors.

Consideration of the foregoing figures on primary production leads to a conclusion that the future rate of increase, besides its dependence on population growth, will be determined in part by changes in the standards of living throughout the world. The industrialization of Russia now under way and rising standards in other countries will be factors tending to maintain and even to increase the world's rate of output. However, political strife or non-economic measures of governments would inevitably curb this growth. On the whole, with the productive facilities at hand, the effective demand for products may be expected to advance appreciably and persistently. American achievements will continue, as in the recent past, to add vigor to the aspirations of other peoples.

WM. HODGKINSON, JR.

Notes on Recent Occurrences

NOW TALK TO ALL ITALY AND SICILY

ON April 6 the transatlantic telephone service was extended to include all of Italy and Sicily, instead of only Northern Italy, Rome and Vatican City.

TALK TO U. S. POINTS FROM CRUISE SHIPS IN DISTANT OCEANS

SEVERAL recent telephone calls from ships at sea to various points ashore have demonstrated afresh the practicability of this new service of communication.

During the past winter and spring, two liners equipped for regular ship-to-shore telephone service made cruises, taking them far out of their ordinary lanes of travel. While these ships, the *Homeric* and the *Belgenland,* were on cruise, ship-to-shore service was maintained whenever possible in an effort to determine the stability of the service when the vessels are far off the beaten track.

From the S. S. *Homeric,* off Alexandria, Egypt, a passenger talked directly with an acquaintance in New York. The call was transmitted by the wireless telephone equipment aboard ship, intercepted at the Forked River, N. J., receiving station and switched over land lines to New York. Traveling from New York by wire, the answering voice was launched into space through the Oceangate, N. J., transmitting station. The distance between the two speakers was about 5,100 miles.

The cruise of the Red Star liner *Belgenland,* which ended on April 28, marked the first occasion on which passengers on a ship circling the globe had been in touch by telephone with persons on shore. From points in the Pacific, off Bombay and in

the Red Sea, passengers on the ship conversed by telephone with friends and relatives in various parts of North America. In the miles of wire and radio circuits involved, these calls broke all records in voice contact between shore telephones and ships at sea.

The service furnished the *Belgenland* was in the nature of an experiment. The American Telephone and Telegraph Company has for more than a year maintained regular service with several liners on the transatlantic run and the directional antenna arrays employed are designed primarily for such use. In view of this the frequency with which contact was established with the *Belgenland,* and the exceptional quality of transmission on several occasions over circuits thousands of miles long are considered gratifying results.

Contact with the ship was maintained through the American Telephone and Telegraph Company stations on the New Jersey coast. The equipment on the ship is owned and operated by the International Marine Radio Company, Ltd., a subsidiary of the International Telephone and Telegraph Corporation.

While the ship was in the Pacific off Central America Dr. Albert Einstein, a passenger, talked over the National Broadcasting network via the Bell System shore stations. With the ship a day's sail west of Hawaii, Douglas Fairbanks, also a passenger, telephoned his wife in New York, and a few minutes later talked over a wire and radio circuit some 9,000 miles long to a friend in San Francisco.

Off the coast of China a conversation was held with London through the British stations near that city. Off Bombay, India, the ship conversed with New York over a radio circuit about 8,000 miles long, the longest all radio ship-to-shore conversation as yet established. Off Ceylon, one of the passengers talked to his family and friends in Cleveland over a "line" consisting of a radio circuit to London, switched there to one of the regular transatlantic radio channels, thence over wires from New York to Cleveland.

When the ship was in the Red Sea one of the women passengers called her daughter in New York and later on, off Alexandria, another passenger talked to Piedmont, California. Other calls completed during the voyage went to cities in New York, Wisconsin, Florida, California, Oregon and several other states.

1931 OPERATING CONFERENCE

THE ninth Operating Conference of the Bell System was held at the Seaview Golf Club at Absecon, New Jersey, from April 30 to May 6. It was attended by the Operating Vice Presidents and General Managers of the Bell Companies, and representatives of the staff of the American Telephone and Telegraph Company, the Western Electric Company and the Bell Telephone Laboratories.

President Walter S. Gifford of the American Telephone and Telegraph Company spoke about the general business situation and some of the more important problems of the System. He also expressed appreciation of the results accomplished by the managements of the companies during the difficult situation which has been experienced during the past year. Vice President Gherardi discussed the general results of operations and referred to the need for a carefully considered construction program and the importance of maintaining reasonable construction and manufacturing programs under conditions like the present. He pointed out that future benefits might be expected from the opportunities for savings in expense which the present situation has brought to light. Emphasis was laid on the importance of maintaining service at a high grade and of still further improving public relations. Vice Presidents Cooper, Page, Carter and Wilson outlined important matters bearing on operations, relations with the public and with Connecting Companies and personnel work.

Reviews of the more important problems in departmental operations were presented by W. H. Harrison, Plant Engineer,

M. B. French, Traffic Engineer, R. H. Burcher, Plant Operation Engineer, and K. S. McHugh, Commercial Engineer, all of the American Telephone and Telegraph Company.

The activities and the problems of the Western Electric Company were outlined by President E. S. Bloom and Vice President C. G. Stoll, of that company.

Special sessions of the conference were devoted to sales and to employment conditions. Representatives of the various companies outlined the situation in their territories and their activities with respect to these matters. Other subjects discussed were budgets and estimating, special services and the development of administrative personnel.

BELL LABORATORIES MEN AWARDED HONORS FOR SCIENTIFIC WORK

ELLIOTT CRESSON MEDALS have been awarded by the Franklin Institute to Clinton Joseph Davisson and Lester Holbert Germer, both of the Bell Telephone Laboratories, "in consideration of pioneer work in the scattering and diffraction of electrons by crystals, and of its direct bearing on our theory of the constitution of matter." Among other holders of these medals are Henry Ford, Elmer A. Sperry, Dayton C. Miller, and Gustaf W. Elmen. The presentation of the medals was made on the occasion of the Institute's annual Medal Day exercises on May 20.

The Franklin Institute has also awarded the John Price Wetherill medal to Edward C. Wente, Acoustical Research Engineer of the Bell Telephone Laboratories, for his development of the condenser transmitter.

On June 9 the honorary degree of Doctor of Science was conferred by Lehigh University upon Francis Ferdinand Lucas in recognition of his contributions to the science of metallurgy and technical microscopy and of his inventions.

GENERAL COMMERCIAL MANAGERS' SALES CONFERENCE

A GENERAL Commercial Managers' Sales Conference, held at Shawnee-on-Delaware, Pennsylvania, from June 5 to 9, was attended by the General Commercial Managers and certain staff representatives of the Associated Companies and of the American Telephone and Telegraph Company. Keith S. McHugh, Commercial Engineer of the American Telephone and Telegraph Company, presided.

At the beginning of the conference, Vice President Gherardi of the American Telephone and Telegraph Company reviewed the results for 1930 and discussed the future prospects of the telephone business in relation to the general business situation.

The first three days of the conference were devoted principally to discussions of the experiences of the Associated Companies with various sales projects, led by J. W. Ord, Sales and Development Engineer, and H. H. Shearer, Directory Engineer, of the American Telephone and Telegraph Company, followed by papers prepared by Associated Company representatives from the standpoint of actual experience in their various territories.

During the latter part of the conference there was a discussion, led by Mr. Ord, of certain aspects of sales management, including: Personnel and Training, Organization, Sales Programming and Results, and Economics of Sales.

Interesting talks bearing on sales activities in the other departments and throughout the System were given by Vice Presidents Cooper, Page, and Carter, Assistant Vice Presidents Waterson and Bickelhaupt, Plant Engineer Harrison, Traffic Engineer French, Plant Operation Engineer Burcher, and Advertising Manager Cook, all of the American Telephone and Telegraph Company.